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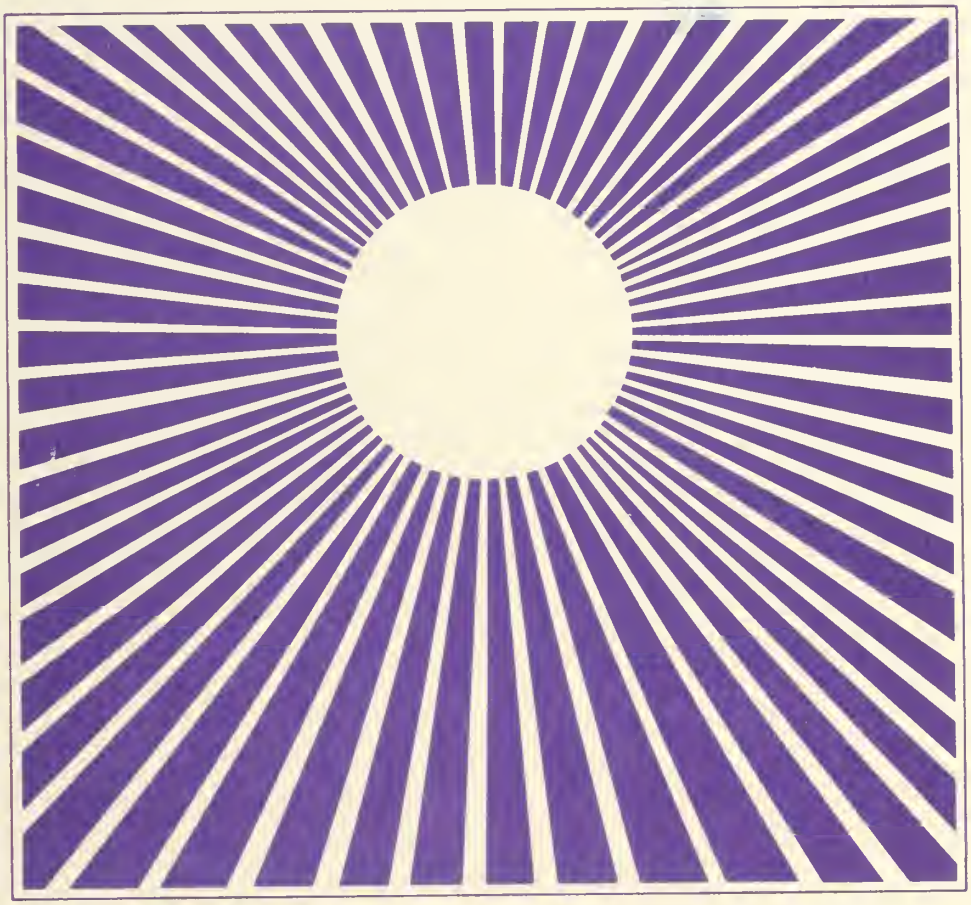
Solar Energy and Nonfossil Fuel Research

A Directory of Projects Related to Agriculture 1980



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Solar Energy and Nonfossil Fuel Research

A Directory of Projects Related to Agriculture 1980

Compiled by
Smithsonian Science Information Exchange, Inc.
Washington, D.C. 20036

for
National Agricultural Library
Cooperative State
Research Service
U.S. Department of Agriculture

Issued December 1981

PREFACE

This publication is the second in the series of annual compilations of agriculture-related projects on solar energy and nonfossil fuel research. It was prepared by the Department's Science and Education Administration, Technical Information Systems (SEA-TIS), in response to the Food and Agriculture Act of 1977 (P.L. 95-113). Section 1450 of the act requires the Department to publish annually a compilation of research projects on this topic.

This edition, produced under contract to the Smithsonian Science Information Exchange, Inc. (SSIE), lists 733 projects selected from notices of research in progress registered with SSIE as of October 1980. Project information appearing in the summaries was taken directly from project descriptions received from Federal, State, and other organizations and institutions, including foreign and private sources. The Current Research Information System (CRIS), the USDA/State project documentation and reporting system for research conducted by the Department, the State agricultural experiment stations, State forestry schools, and other cooperating institutions, was a major source for many projects listed here.

The 1980 directory updates the 1979 directory that contained projects active from 1976 through early 1979. In addition to listing new projects through October 1980, this directory contains new progress reports for many of the projects published in the previous directory. Numerous projects that appeared in the previous directory and that remained active through October 1980 also are included regardless of any change in the project summaries.

Consistent with provisions of Section 1450 of the 1977 act, topics in this directory pertain to solar energy and nonfossil fuel research and its application to agriculture and the rural community. Studies relating to farm operations, structures, and equipment, as well as those applicable to farm dwellings, are included.

The arrangement of chapters within the Description of Research Projects section is patterned after the CRIS special classification for agricultural energy research and development. Specifically included are projects relating to the development of technologies for use of alternate forms of energy (solar, wind, and geothermal), and those dealing with the substitution of critical sources of energy by renewable energy sources and forms (agricultural and forestry products and residues, energy farming and biomass). Research on other nonfossil energy sources, primarily waste heat, and studies involving multiple sources of energy are listed in separate chapters. Projects on conservation and use of energy, those dealing with noncritical sources, such as coal, lignite, oil shale, and peat, and projects relating to consequences of energy production, availability and use (reclamation, renovation, and environmental effects) were considered out of scope and, therefore, were not listed here.

Latest progress reports on many ongoing projects listed, as well as project descriptions of research on other agricultural energy topics, are available to personnel of the Department and State cooperating institutions through the CRIS retreival service at USDA and to the public through the commercially available CRIS on-line file. For access and availability contact: Current Research Information System (CRIS), U.S. Department of Agriculture, National Agricultural Library Building, Beltsville, Maryland 20705.

Users in the Department, State cooperating institutions, and other government agencies may obtain free copies of this publication by sending a self-addressed mailing label with their request to: Library Operations Division, National Agricultural Library, Beltsville, Maryland 20705. Limited copies are available free to the public.

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USER GUIDE
SAMPLE PROJECT DESCRIPTION

Directory Number
4.0104
Chapter Number
Sequence within Chapter

Project Title — **CONVERSION OF ANIMAL WASTES TO METHANE GAS AND TO SINGLE CELL PROTEIN USING PHOTOSYNTHETIC BACTERIA**

Principal Investigator, Performing Organization, and Address — *J.C. Ensign,* University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Bacteriology, *116 Agricultural Hall, Madison, Wisconsin* 53706

Project, Grant or Contract Number — (WIS02342)

Project Summary

OBJECTIVE: The purpose of this investigation is to develop procedures for recycling of farm wastes. The products to be produced are methane gas, microbial protein and fertilizer. Another goal is concomitant formation of a low nutrient, non-polluting effluent solution. The ultimate goal is operation of rurally located factories for waste recycling.
APPROACH: Anaerobic fermentation of cow and chicken manures at meso- and thermo-philic temperatures produce methane gas and high levels of volatile fatty acids. Comparisons of various fermentation operations will be made to optimize formation of gas and fatty acids. A separation step removes insoluble materials which can be used as fertilizer or feed supplement. The supernatant fluid is used to grow photosynthetic bacteria which convert most of the organic matter into protein. A continuous flow system for efficient production of protein will be studied. The next phases of the investigation will involve scale up to pilot plant and, if economically feasible, to factory size operations.
PROGRESS: The purpose of this investigation is to efficiently convert animal wastes, particularly chicken manure, to energy as methane gas and to single cell protein. A 20,000 gal. fermentor located on a farm at Ripon, Wisconsin, has been in operation for several years. The methane generation capacity has been improved until 4,000 cu. ft./day is now being produced. This amounts to a value of methane of only $4.05 per day. We are convinced that a major consideration for treating farm animal wastes by fermentation is to recover a protein-rich material to be recycled as animal feed. The particulate matter in the digestor effluent contains 20-25% by dry weight of protein. The liquid fraction is converted by the use of photosynthetic bacteria into single cell protein. Over half of the initial weight of chicken manure can be converted to high quality single cell protein using the combined anaerobic digestion-photosynthetic bacteria treatments. Energy as methane gas is also produced and there are no potentially polluting effluent materials to deal with. Laboratory scale experiments indicate that the process is economically feasible.

Supporting Agency — SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Wisconsin

ARRANGEMENT OF ENTRIES

Projects in this publication are listed by chapter and assigned unique identification numbers for locating project descriptions referenced in the indexes.

The DESCRIPTION OF RESEARCH PROJECTS contain all project summaries alphabetically arranged within each chapter by State, performing organization,and principal investigator. Within this sequence each project is assigned a unique five-digit number (for example, 4.0104) indicating the chapter (left digit) and the position in the chapter (right four digits) in which the summary is located. A project which contains elements applicable to more than one chapter is placed in that chapter which best depicts the major energy component of the project.

The SUBJECT INDEX is based on a classification system developed by SSIE in which index terms are arranged in hierarchies relfecting relationships between broader and narrower subjects. To avoid proliferation with excess entries, highly specific terms, in many instances, are subsumed under those at the next higher generic level. A maximum of three levels are provided in the index. "See" and "See Also" cross-references are included to assist in locating topics. Each index term is followed by the project title and the unique five-digit number for locating the project summary, as in the following example:

ECONOMICS
Economic Feasibility
CONVERSION OF ANIMAL WASTES TO METHANE GAS AND TO SINGLE CELL PROTEIN USING PHOTOSYNTHETIC BACTERIA **4.0104**

For further assistance, the subject index is arranged in a dictionary format in which the first and last main headings on opposite pages also appear in the top margins.

The INVESTIGATOR INDEX is an alphabetical listing of all investigators cited on the source document provided to SSIE. An asterisk is used to designate the principal investigator, and only this name appears in the project description.

The PERFORMING ORGANIZATION INDEX lists, alphabetically, the name of the institution or laboratory conducting the investigation.

The SUPPORTING AGENCY INDEX consists of a single alphabetical listing of both Federal and non-Federal sources of support.

DESCRIPTION OF RESEARCH PROJECTS

1. SOLAR ENERGY

1.0001,

POTENTIAL FOR CONVERSION AND UTILIZATION OF SOLAR ENERGY IN POULTRY PRODUCTION

R.N. Brewer, Auburn University, Agricultural Experiment Station, Dept. of Poultry Science, *Auburn, Alabama* 36830 (7098-20400-0009A(4))

OBJECTIVE: Determine the amount and types of fuel used in the production of poultry products, and to probe the feasibility of replacing part or all of this energy requirement with solar energy.

APPROACH: Current sources and amount of heat energy used in poultry production will be determined by field surveys and analysis of industry records. An economic analysis of the impact of decreasing supply and increasing cost of energy on production costs, and the effect on consumer costs will be conducted. These data will be used to evaluate the economic feasibility of using solar energy in poultry production.

PROGRESS: During this period the summary objective was to work on intergration and optimization of a solar system for brooding poultry. The solar heated poultry research facility outlined in early reports was used in all studies. Specific trials were designed to allow for maximum data collection including performance of solar collection and delivery system, brooding and poultry management parameters, and accompaning meterolgical data. A series of four experiments were conducted to evaluate the operational efficiency of the complete solar heating system including collection, storage, and delivery of energy to the research pens. In this phase a comparison was made between total room heating using fin tube convectors and total room heating using concrete slab brooders. These two systems utilized relatively low temperature solar heated water with an electric auxiliary back system. These two systems performed satisfactorily and were statistically not different from rooms heated with LP gas brooders. Major problems encountered during this first full year of testing included; scheduling of chick placements during periods of extended cloudy, cold weather and the availability of sunshine frequency and intensity during the colder winter months.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Alabama - North Mississippi Area

1.0002,

ANNUAL CYCLE SOLAR REGENERATION OF DESICCANT FOR CROP DRYING

J.W. Fletcher, Lockheed Missiles & Space Co. Inc., *4800 Bradford Dr., Huntsville, Alabama* 35807 (7004-20190-016-G(1))

OBJECTIVE: Evaluate the performance of the solar regenerated desiccant pond concept and determine its technical feasibility and practicality. Additional objectives are to assess the economic potential of the concept and develop design criteria for a prototype system.

APPROACH: A system analysis will be performed on the proposed solar drying system to define the design conditions for the crop drying and regeneration system. Following this an experimental version will be designed, constructed and evaluated. The analysis of these tests will include an economic feasibility study and a plan for commercialization.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0003,

AGRICULTURAL ENGINEERING PROBLEMS

L.D. Allen, University of Alaska, Fairbanks Campus, Inst. of Agricultural Sciences, *P.O. Box AE, Palmer, Alaska* 99645 (ALK-074-5205)

OBJECTIVE: Evaluate, document and report special, peculiar, or unique agricultural engineering problems and situations encountered in Alaska's subarctic and arctic environments.

APPROACH: Where a showing of need justifies the cost and effort, special undertakings will be initiated aimed at finding satisfactory solutions for a minimum investment of time and funds, and with due regard to existing program priorities and commitments.

PROGRESS: Environmental enhancement provided by structures and culture practices which conserve heat or moisture were used to stimulate plant growth and yield. Crops of tomatoes, cucumbers, and peppers benefited from each increased level of microclimate improvement. Increased national interest in the utilization of solar energy, and homesteader requests stimulated by the Tanana Loop land sales at Delta, Alaska have increased requests for information on the subject of solar energy collection. Areas of particular agricultural interest for solar energy usage in Alaska have been for grain or other crop drying. A solar grain drying design and installation is planned for the Matanuska Farm in 1979. A particularly promising application is the use of solar energy powered fans for the cooling of greenhouses. Cooperation in designs and assistance to persons interested in solar assisted and thermally efficient homes has been given. Wind and solar records have been helpful in evaluating the value of wind and sunshine as alternate energy sources.

SUPPORTED BY Alaska State Government

1.0004,

EVALUATION OF THE EFFECTIVENESS OF DUAL TROMBE WALL SYSTEMS AND GREENHOUSE IN A HYBRID (PASSIVE AND ACTIVE) SOLAR HOME

A. Herron, (No Performing Organization Reported), *Arizona*

SUPPORTED BY U.S. Dept. of Energy

1.0005,

ADDING MARKET VALUE TO HARVESTED ARIZONA VEGETABLES AND GRAIN BY PROCESSING WITH SOLAR ENERGY

R.E. Foster, University of Arizona, Agricultural Experiment Station, Dept. of Plant Sciences, *Tucson, Arizona* 85721 (ARZT-172381-56-14)

OBJECTIVE: Utilize surplus vegetables by dehydrating 'completely.' Improve shipping ability of Arizona vegetables and reduce transit costs and handling losses by removing small amounts of moisture at origin, restoring it at destination. Permit early grain harvest by artificially drying slightly immature grain. Accomplish all of above through use of solar energy.

APPROACH: Use fossil fuel to simulate solar powered dehydrator. Establish machine requirements and develop methods. Obtain harvested produce, apply drying treatments, store, restore to original form, evaluate by appropriate comparisons. Compare artificially dried grain with full term grain. Determine proper timing by comparing different ages.

PROGRESS: With this project study is being conducted on two distinct aspects of dehydration: (1) 'Complete' or the removal of 85-95% of moisture which results in a dry product with protracted storage life. Examples are dried onion flakes and dry potato powder. (2) 'Relaxed' or removal of 5-15% of the moisture resulting in a slightly wilted product easier to ship without injury and cheaper to ship due to reduced weight. Some Arizona vegetables have been found to be poor candidates for complete dehydration because of poor quality of product upon rehydration. Experiments showed that when broccoli and cauliflower were 'Complete' dehydrated slowly (as with a low-temperature, slow air movement energy-conserving solar dryer) the product was better than that dried quickly. Final quality still need improvement. Both crops, however, respond well to 'Relaxed' dehydration and rehydration. Preliminary studies revealed that high-temp 'Relaxed' drying made tissue more susceptible to fungus growth while low temperature drying reduced spoilage. 'Relaxed' muskmelons resist mechanical damage compared to full turgid fruit. Additional experiments are planned to assess differences in spoilage potentials in this product.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Arizona

1.0006,

FRUIT DEHYDRATION USING GREENHOUSE STRUCTURES

R.L. Price, University of Arizona, Agricultural Experiment Station, Dept. of Nutrition & Food Science, *Tucson, Arizona* 85721 (7004-20510-020-A)

OBJECTIVE: Determine feasibility of using greenhouse structures in hot, dry climates for dehydration of fruits and vegetables. Determine fruit and vegetable cultivars best compatible for this type drying. Recommend most suitable structures as drying systems.

APPROACH: Compare, prepare and select fruits and vegetables for dehydration in three structures: Horizontal and vertical air-flow greenhouses and a soil desiccant cold frame. Compare with conventionally dried products using forced air oven. Compare operation in different temperatures and relative humidities. Compare dried products chemically and organoleptically for nutritional content, general quality and consumer preference. Derive computer simulation model based on experimental measurements, to predict applicability of results to other regions.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0007,

SOLAR ENERGY UTILIZATION IN DAIRIES

F. Wiersma, University of Arizona, Agricultural Experiment Station, Dept. of Soils Water & Engineering, *Tucson, Arizona* 85721 (7092-20401-012A)

OBJECTIVE: Develop design criteria for use of solar energy for heating and cooling needs in dairy facilities in various climatic regions, develop a computer simulation model for evaluation of solar energy systems for dairies, and determine economic feasibility of use of solar energy systems for dairies.

APPROACH: Basic design parameters developed by ARS-USDA at Beltsville, MD, for use of solar energy in milking phase of dairy production, will be adapted to various climatic conditions, with emphasis on desert climates of Southwest. A computer simulation model will be developed to facilitate evaluation, including economic feasibility of solar energy systems in dairies. Plans will be prepared for use of solar energy in a research dairy in Arizona for verification of studies.

PROGRESS: A small water heating system is in operation to use solar energy to provide part of the energy required to meet the hot water needs at the Agricultural Experiment Station dairy milking 130 cows. Computer simulation of solar water heating is in progress to quantify performance and evaluate economic comparisons. Hot water use is being measured at over 100 cooperating dairies that represent a cros section of type, size and geographical location to provide a basis for developing design criteria for water heating systems for dairies using alternate sources of energy.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Alabama - North Mississippi Area

1.0008,

ENERGY IN WESTERN AGRICULTURE - REQUIREMENTS, ADJUSTMENTS, AND ALTERNATIVES

D.W. Williams, University of Arizona, Agricultural Experiment Station, Dept. of Soils Water & Engineering, *Tucson, Arizona* 85721 (ARZT-171493-51-20)

OBJECTIVE: Assess contributions of, and prospects for, alternative technologies and policies for dealing with changes in energy availability.

APPROACH: An energy balance model (digital computer) will be developed to analyze the energy expended in each of the production operations normally used in Arizona for producing cotton, sorghum, sugar beets, alfalfa, and wheat. Using the model developed above, the energy requirements of alternative technologies will be evaluated, both from the standpoint of total energy and energy derived from each particular energy source (electricity, diesel, natural gas, etc.). Identification of alternative technologies is not a straight forward process, however several general areas show promise for energy savings. Fertilizer substitutions. Alternate irrigation techniques. Changes in cultural practices. Improvements in ma-

chinery maintenance. The project will evaluate changes in each of these areas.

PROGRESS: A gasifier to partially combust agricultural residues and yield a low Btu gas which can be burned or used in engines was constructed and tested. Wheat straw was successfully gasified but feeding problems were encountered unless residues were cubed or otherwise compacted. Gas cleaning developments were also found to be necessary for use with an engine. Associated energy research demonstrated the use of solar energy to heat water for use in dairy milking parlors, but also indicated heat reclamation devices used in conjunction with milk coolers may provide the required heating energy. Another year of cotton production studies resulted in energy savings with chisel-list tillage and alternate furrow irrigation while maintaining yields. Construction of a 150 kW solar-powered irrigation pumping plant was begun on a farm near Coolidge. Associated irrigation and pumping experiments will evaluate energy conservation methods. Energy use schedules were developed for various stationary on-farm applications. These indicated irrigation pumping requirements with deep subsurface water sources are much greater than for other on-farm applications such as livestock facility heating and crop drying. Thus, use of solar power plants sized to meet pumping requirements may not be increased substantially through use of the excess energy for other on-farm applications.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Arizona

1.0009,

RESIDENTIAL ENVIRONMENTAL CONTROL UTILIZING A COMBINED SOLAR COLLECTOR GREENHOUSE

C.N. Hodges, University of Arizona, Environmental Research Lab., *Tucson, Arizona* 85721 (12-14-7001-544)

The project objectives are to evaluate the economic and environmental desirability of developing greenhouses as part of residential buildings to reduce the requirement for fossil fuels, to enhance the home environment, and to add food production potential. The approach is to modify existing greenhouse/office structure and instrument to monitor the environment, including amount of solar energy available to the greenhouse and the percentage of this that can be utilized within the connecting office (residence); compare plant growth and resulting environment with those in an unattached greenhouse; and evaluate use of liquid foam between layers of plastic greenhouse covers for nighttime insulation, interaction between residential environment and optimum plant growing conditions in a combined greenhouse and residence, and evaluate the potential of combining greenhouses and residences. Vegetables were grown in the greenhouse-office complex under summer cooling conditions. Two models of greenhouse cooling were compared, a single-stage evaporative cooling system and a two-stage system. The two-stage system maintained greenhouse air temperature about 5 degrees F lower than the direct (single-stage) cooling system. During the winter the greenhouse/office unit has been warmed during the day by the heat energy entering the unit, as the greenhouse structure during daylight hours is itself acting as a solar collector. The ClearView solar collector, which forms the south wall of the greenhouse, is in operation and will separately collect solar thermal energy during daylight hours for storage in a rockbed. The stored heat is subsequently used in the heating of the greenhouse/office or residential spaces during the nighttime and early morning hours. The production of vegetables continues to be over the estimated yield, except for October. Vegetables are being produced on an average of over 1.7 pounds per day.

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Div. of Solar Energy, Office of Solar Application for Buildings

1.0010,

SOLAR POWERED WATER HARVESTING SYSTEM

D.L. Larson, University of Arizona, School of Agriculture, Dept. of Soils Water & Engineering, *Tucson, Arizona* 85721 (EM-78-G-03-1914)

SUPPORTED BY U.S. Dept. of Energy

1.0011,

ENERGY CONSERVATION ALTERNATIVES FOR ARKANSAS RURAL RESIDENCES

T.R. Rokeby, University of Arkansas, Fayetteville Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fayetteville, Arkansas* 72701 (ARK00841)

OBJECTIVE: Develop, evaluate and optimize methods of energy conservation for Arkansas residences. Evaluate and develop systems for use and control of alternative energy sources, principally solar, for heating rural residences.

APPROACH: Apply a dynamic mathematical model of typical Arkansas residences to predict thermal performance, including energy consumption. Use the model to select optimum energy conservation practices for Arkansas residences. Verify predicted performance by observation of actual residences incorporating such conservation methods. Apply the model to predict performance of solar heating systems for Arkansas residences and validate by observation of two or more solar heated residences to constructed. Determine fuel and power consumption, construction and operating costs of solar heated residences and compare with conventional residences.

PROGRESS: A solar collector of the hot air type suitable for residential heating has been designed. Equipment to test this unit has been selected and is being assembled. Planning of a solar heated residence for an experiment station employee is under way. This planning involves Extension as well as Experiment Station personnel.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Arkansas

1.0012,

BROODING CHICKS WITH SOLAR ENERGY

T.R. Rokeby, University of Arkansas, Fayetteville Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fayetteville, Arkansas* 72701 (ARK00923)

OBJECTIVE: Develop systems and operating methods for using solar heat to brood chickens, with emphasis on retrofitting existing buildings. Develop systems and methods for conserving heat energy in brooding chickens. Evaluate the physical and biological performance of the proposed conservation measures and solar heating systems. Determine the economic feasibility of using solar heating and conservation measures for brooding chickens.

APPROACH: Weather and environmental conditions and energy flows in a solar heated commercial broiler house will be studied. Biological performance, including mortality, weights and feed conversion will be monitored. Economic factors, including returns from a standard grower contract, will be determined. Resulting data will be used as a base for improved designs, economic analyses and computer modeling of energy management systems.

PROGRESS: The five flocks of broilers raised in the solar heated house in 1978 showed above average feed conversion and live weight. Fuel savings (natural gas) were 73% for the March-April flock and 90% for the October-December flock, as compared to a group of commercial broiler houses in the area. No comparison is available for the January-March flock, no fuel was used for the summer flocks. During the winter heating season of 1977-78, Natural Gas (NG) consumption was measured for the experimental University of Arkansas solar heated broiler house. The house has approximately one-half the capacity of commercial broiler grower in the area. Solar energy heats air in the collector which is then blown into the broiler house through ducts when heat is required. The experimental house did require less conventional heat energy than commercial houses that had flocks in them during the same time period. More electrical energy was used with the solar house than the commercial houses in order to power the fan system that blows heated air into the house. Preliminary economic analysis indicates that at current prices and assuming that winters will average out to be like the 1977-1978 winter, this solar heating system is not economically feasibility. Further analysis is being done during the 1978-79 winter heating system.

SUPPORTED BY Arkansas State Government

1.0013,

SOLAR HEATED SEPTIC TANKS FOR DEAD POULTRY DISPOSAL

W.K. Warnock, University of Arkansas, Fayetteville Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fayetteville, Arkansas* 72701 (ARK00935)

OBJECTIVE: Demonstrate the use of septic tank-filter field systems for poultry disposal. Demostrate the effects of heating and agitation on the efficiency of septic tanks for poultry disposal. Investigate overall energy efficiency of solar heated septic tanks. Investigate the economic incentives for using heated septic tank-filter field systems for dead poultry disposal.

APPROACH: Two solar heated septic tank systems with one control system will be located on the University of Arkansas Main Experiment Station Fayetteville, Arkansas. Water samples will be collected monthly from each septic tank's effluent and from two well points installed below each filter field. Water samples will be analyzed for concentration of total solids, suspended solids, volatile solids, etc. Two solar collector systems will maintain optimum biological temperatures in the septic tanks. The relative economics of heated septic tank systems for dead chicken disposal will be determined by comparing the construction and operating costs of the research units with other disposal methods.

PROGRESS: Design details, and equipment selection and procurement for three solar heated dead poultry digestion systems are being finalized. It is anticipated that the system will be placed into operation during the Summer of 1979. The economic analysis for this multidisciplinary project will be undertaken in the last years of the project, no analysis was undertaken this year.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Arkansas

1.0014,

COMMUNITY CANNING CENTER SOLARIZATION

A. Naccach, Aton Solar Meg, *Novato, California* 94947 (EM-78-G-03-1955)

SUPPORTED BY U.S. Dept. of Energy

1.0015,

HEAT AND FOOD PRODUCING SOLAR GREENHOUSE FOR NORTHERN CALIFORNIA DEMONSTRATION

L. Nelson, Environ Mental, *Berkeley, California* 94710 (EM-78-G-03-1958)

SUPPORTED BY U.S. Dept. of Energy

1.0016,

SOLAR HEATED GREENHOUSE

Unknown, Jojoba International, *Carpinteria, California* 93013 (EM-78-G-03-1960)

SUPPORTED BY U.S. Dept. of Energy

1.0017,

OPTIMIZED SOLAR WOOD STOVE DOMESTIC WATER HEATING SYSTEMS

Edmondson, Millcreek Energy, *Healsburg, California* 95448 (EM-78-G-03-1933)

SUPPORTED BY U.S. Dept. of Energy

1.0018,

SOLAR AND WIND ELECTRIC GENERATION OF LOW COST

O.J. Smith, Smith Consulting Engineers, *Berkeley, California* 94708

The construction of a Smith-Chalk wind turbine capable of 10 kW at 28 mph and of very rugged low-cost high reliability design is described. The design of solar-thermal-electric power plants of the modular type suitable for mass production of small components with no expensive hand work or expensive field engineering is discussed. The design uses conventional technology applicable to large cost savings due to mass production and modular pattern to assemble the desired power level. Three designs have been made: one megawatt, twenty megawatts, and 100 megawatts. Both base-load and peaking-load designs with 4 hours and 16 hours heat storage were designed. A 20-foot-diameter wind turbine was built which required only a drill, power hacksaw, bending brake, and welder for tools. In mass production, these turbines would cost only $5000 each. Minimum cost computer programs were used to improve the designs.

SUPPORTED BY U.S. Dept. of Energy

1.0019,

DEMONSTRATE COMMERCIAL FEASIBILITY OF HEATING A GREENHOUSE WITH COMMERCIALLY AVAILABLE SOLAR HEATING DEVICES

M.H. Hodge, Suntek Research Associates, *506 Tamal Plaza, Corte Madera, California* 94925 (EG-77-C-05-5456)

SUPPORTED BY U.S. Dept. of Energy

1.0020,

UTILIZATION ECONOMICS AT THE REGIONAL RESEARCH LABORATORIES

M.E. Miller, U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div., *800 Buchanan St., Albany, California* 94710 (NEA-12-107-06-02)

OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for products of the different regions and their comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra and inter-regional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.

APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.

PROGRESS: Economic advisory and research services were provided administrators and scientists at the regional research laboratories on the feasibility and consequences of various new technological developments. Contributions of economic services were to (a) an AID sponsored study of market potential of composite flour technology in developing countries, (b) a cooperative study between SEA/AR and Oklahoma State University on model tannery operations, (c) a cooperative study involving SEA/AR, FAS and the National Renderers Association on foreign market potential of tallow-based soap detergents, (d) a cooperative SEA/AR and ESCS assessment of potentials for additional use of crop residues in cattle rations, and (f) an assessment of feasibility and impacts of solar energy uses in agriculture. The latter three studies are continuing under work unit/Project No. NEA-12-107-11-00. Initial results indicated high fructose corn sweetener was not a perfect substitute for other sweeteners used in manufactured products. An update of the analysis contained in a 1975 report on PRO-XAN indicated commercial feasibility was greatly enhanced by new processing technology. An update of 1975 estimates of cost of producing Kenaf verified its continuing potential as a resource for manufacturing paper.

SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div.

1.0021,

OPTIMIZING WET FRACTIONATION OF FORAGES FOR IMPROVED FEED PRODUCTS

R.H. Edwards, U.S. Dept. of Agriculture, Agricultural Research, Western Regional Research Center, Feedstuffs Research, *800 Buchanan St., Albany, California* 94710 (5102-20520-016)

OBJECTIVE: Prepare improved animal feeds from field crops, especially alfalfa, with emphasis on reducing energy requirements and costs, and increasing nutritional value.

APPROACH: Wet processing of forages will be developed further by: Optimizing LPC drying conditions to maximize nutrient availability; preparing LPC-encapsulated fats for use in high energy feeds; eliminating pigmenting xanthophylls in LPC for high-level feeding; reducing energy requirement via recovering process waste heat, optimizing grinding and pressing, using solar energy (wilting) for preliminary moisture removal, and adaptations for 'on-the-feedlot' processing, including fresh feeding and ensiling press cake; and using leaf-enriched raw material, and using green crops in addition to alfalfa, to extend the operating season and region. In collaboration with a commercial alfalfa dehydrator, and with financial assistance from the Department of Energy, the LPC process will be expanded to commercial scale; process design, operation, and product marketability will be optimized. Digestibility of hays, silage, and LPC press cake will be improved by cell disruption.

PROGRESS: Alfalfa leaf protein concentrates (LPC, Pro-Xan) have been sent to three major feed manufacutrers and/or users for evaluation in commercial broiler feeds and to university collaborators for evaluation in milk replacers for calves. Further economic analyses have shown that conversion of an existing alfalfa dehydration plant to a Pro-Xan plant processing 40 tons of fresh alfalfa/hour should cost approximately $2.3 million and return in excess of 40% of invested capital per year. Under terms of a memorandum of understanding and grant from the Dept. of Energy, technical assistance is being provided to the Valley Dehydrating Co. (VDC), Sterling, CO, to commercialize the Pro-Xan process. Information relating to plant layout, material balances, equipment specifications and suitability has been supplied to VDC and other interested commercial vendors. Sufficient equipment to convert the VDC alfalfa dehydration plant to a 30 ton/hr Pro-Xan plant was installed by October 5 to operate the plant for the final three days of the season. Analyses show that the VDC plant should require 35% less energy than a conventional plant to dehydrate an equivalent amount.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Western Regional Research Center

1.0022,

IMPROVED FRUIT AND VEGETABLE PROCESSING AND PRODUCTS

D.F. Farkas, U.S. Dept. of Agriculture, Agricultural Research, Western Regional Research Center, *800 Buchanan St., Albany, California* 94710 (5102-20510-010)

OBJECTIVE: Increase quality, stability and nutritive values of fruit and vegetable products via development of more efficient processing and handling methods.

APPROACH: New forms of fruits and vegetables, such as pre-cored apples, chopped lettuce, and cut asparagus, will be studied to determine factors affecting quality and nutrient retention. Systems for handling and processing such new forms will be integrated with those for mechanized harvesting and subsequent marketing. Chemical, and other, techniques will be developed for pre-processing highly perishable commodities, e.g., peaches, prior to final processing. New methods will be sought to prevent enzymatic browning with low or no use of sulfur dioxide. Effects of new processing methods on nutrients will be determined; potential food use of processing discards will also be studied.

PROGRESS: Microwaves were used to aid rapid heating of non-oil-containing fexible pouches. Taste tests showed a superior product by combining a one-minute microwave exposure with a ten-minute hold in water, at 250-260 F under pressure. Microbiological tests indicated non-uniform microwave energy distribution in 5-oz. pouches in a cylindrical pressure vessel. Further work is needed to improve energy distribution. Intermediate-moisture fruits and vegetables were prepared without artifical plasticizers. Vegetables were given lactic-acid fermentation prior to drying. Lower temperature drying methods (120-140 F), without blanching or sulfur pretreatment, were tested to demonstrate effect of energy-saving, solar- assisted drying methods on fruit and vegetable quality at intermediate moisture levels. Diced cling peaches were frozen in bulk, dehydrofrozen, or stored in refrigerated solutions containing mixtures of sucrose, citric acid, ascorbic acid, sodium benzoate, and potassium sorbate, to compare effects of these storage conditions on quality of peaches packed in individual- serving-sized plastic containers. Treatments and storage conditions to extend storage life of fresh shredded lettuce were developed. Pouches of shredded lettuce retained marketable quality 2.5 times longer at 2 C than at 10 C. Slicing with a sharp blade produced best results. Chopping, small shred size, physical damage, moisture of cellular fluids on lettuce surface, high microbial loads all reduced storage life.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Western Regional Research Center

1.0023,

REDUCING ENERGY USE IN PROCESSING FOODS, ESPECIALLY FRUITS AND VEGETABLES

C.C. Huxsoll, U.S. Dept. of Agriculture, Agricultural Research, Western Regional Research Center, *800 Buchanan St., Albany, California* 94710 (5102-20510-016)

OBJECTIVE: Develop better systems for processing fruits, vegetables, and other foods such that energy use is cut but product safety, quality, and nutritive value are retained.

APPROACH: Examine the most energy-costly steps in food processing systems to improve their efficiency of energy use. For example, study present blanching practices for various foods, determine minimum blanching temperatures and times, and test on laboratory and pilot scale. Extend the 'double-dip' lye application procedure to all major fruit and vegetable commodities that require peeling. Evaluate membrane processing (e.g., reverse osmosis) for reducing energy use in concentrating foods to purees and pastes. Determine the feasibility of using solar energy to assist fruit and vegetable drying processes. In all cases, determine effects on product safety, quality, nutritive value, and stability. Assist in pilot-to-commercial scale up and adoption.

PROGRESS: An inflated polyethylene dome was built and tested as solar dryer for fruit. Results showed a very high air flow needed to prevent moisture condensation on the film. Basic air-drying data was obtained on peaches in the temperature range normally encountered in solar dryers, so that solar systems can be modeled and analyzed. A novel inexpensive heat recovery system for use by seasonal food dehydrators has been demonstrated; payout is estimated to be two to five seasons depending on the length of the processing season. A two-thirds energy savings from eliminating hauling of husk and cob could be realized if the unit kernel sweet corn system was applied to the field separation of kernels. Mechanical harvester concepts are evaluated to determine optimum design requirements. Methods for reducing energy associated with wet corn milling have been developed. Results showed that the greatest opportunity for energy saving is in the dewatering of starch and gluten streams. Tests with an 8-ft high, continuous, half-cube fermenter showed that 96% conversion of sugar to ethanol could be achieved in 3-4 hours. Increased conversion could be obtained by baffling the fermenter to inhibit gas-lift pumping, a characteristic of all continuous fermenters. Equations were developed to quantify the findings.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Western Regional Research Center

1.0024,

SOLAR ENERGY

J. Otvos, University of California, Berkeley Campus, Lawrence Berkeley Lab., *Berkeley, California* 94720

Methods development for utilization of solar energy; green plant photosynthesis; sensitized photodecomposition of water; sensitized photovoltaic devices; hydrocarbons and energy from plants. (DOE/ER-0002)

SUPPORTED BY U.S. Dept. of Energy, Office of Energy Research

1.0025,

PHOTOCHEMICAL CONVERSION OF SOLAR ENERGY

L. Packer, University of California, Berkeley Campus, Lawrence Berkeley Lab., *Berkeley, California* 94720

Biotechnological applications of solar energy; photoelectric potential generation; catalytic systems in chloroplasts; light-triggered catalysts in micro-organisms such as cyanobacteria and halobacteria; hydrogen production by chloroplasts in vitro and production and consumption by cyanobacteria; applications to artificial convertors. (DOE/ER-0002)

SUPPORTED BY U.S. Dept. of Energy, Office of Energy Research

1.0026,

SPECIAL FOREIGN CURRENCY AWARD (IN INDIAN CURRENCY) FOR BIOLOGICAL APPLICATIONS OF SOLAR ENERGY INTERNATIONAL SYMPOSIUM

L. Packer, University of California, Berkeley Campus, School of Letters & Science, Dept. of Physiology & Anatomy, *Berkeley, California* 94720 (INT7820794)

This project is to support U.S. participation in a symposium on the biological application of solar energy to be held in Madurai, India. The symposium will bring together Indian, U.S., European and Australian scientists who will discuss the growing knowledge of the biological systems which have evolved into highly efficient and specialized mechanisms for energy transformation. The application of this knowledge to the improvement of agricultural products, for the production of specialized chemicals and for energy production in the form of combustible fuels will be discussed. Goals for application of this knowledge into these areas will be discussed, both for the near-term and long-term goals. The main areas of the symposium program include: enhancement of photosynthetic activity; explonng nitrogen and hydro-

gen metabolism, and the use of biological catalysts in development of artificial devices such as biochemical fuel cells, and photovoltaic devices.
SUPPORTED BY U.S. National Science Foundation, Directorate for Scientific Technological & Internat. Affairs, Div. of International Programs

1.0027,
FOOD ENGINEERING

R.P. Singh, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Davis, California* 95616 (CA-D#-AER-2969-MH)
OBJECTIVE: Conduct fundamental investigations, in areas such as thermodynamics, heat and mass transfer, and fluid flow, that have potential application to food processing problems. Conduct discipline-oriented investigations of unit operations having direct application to food processing. Develop new systems and equipment to improve food processing operations.
APPROACH: Designed experiments for laboratory and field executions are expected to yield results that can be expanded to production or full-scale use.
PROGRESS: Research accomplishments in the area of drying of medium grain rice varieties include development of a mathematical equation to describe single layer drying of rice, desorption equation of rice from 10 degrees C to 40 degrees C, development of a computer simulation of the drying process and studies on tempering of rice during drying. It was found that tempering times of 3 hours and less may be adequate for certain drying conditions. Use of ambient air to cool rice immediately after drying results in increased cracking. Another study emphasized mathematical and experimental drying of walnuts with unheated air. Studies conducted on energy use of an atmospheric retort revealed that use of an outside heat exchanger resulted in improving energy use efficiency from 30% to 55%. The payback period of the modification was calculated to be one season for peach processing. Analysis of an energy survey of citrus packing plants in California revealed that the major type of energy source used was electricity (80%). Lemon packing is twice energy intensive when compared with orange packing. A study was conducted on determination of surface heat transfer coefficient for canned foods heated in silica beds. A surface heat transfer coefficient of 340 W/m 2degrees C was obtained. Heating rates were comparable for convention heated foods processed in silica beds and conventional steam retorts.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

1.0028,
DRYING ANIMAL WASTES WITH SOLAR ENERGY

B. Horsfield, University of California, Davis Campus, School of Engineering, *Davis, California* 95616 (12-14-7001-559)
The project objectives are to determine the feasibility of drying animal wastes with solar energy in order to eliminate use of fossil fuel for waste drying, reduce fuel used for transporting waste, and to improve the utilization of waste as plant nutrients. A manure dryer capable of drying livestock wastes with solar heat, with a year's manure storage capability, will be designed and built. The unit will be used to process waste from a swine production unit. Performance of the unit will be evaluated with respect to drying efficiency and rate, and efficiency of manure nutrient maintenance. The unit will be evaluated for economic feasibility. A mechanism has been designed and tested which will automatically stir thin layers of poultry manure. The device has a day timer, an interval timer, and a pass counter such that a flexible stirring program can be established. The mechanism has been installed in a commercial poultry farm near Riverside, California. The device operates on a track 10 feet wide and 160-feet long. It is capable of self-unloading the dried poultry manure to a shallow pit at one end. Initial tests have been run on four different depths of manure with an initial moisture content of 60% (WB). Samples were taken every two hours for moisture content and, less frequently, samples were taken for nitrogen analysis. Throughout the tests, weather data were continuously taken. This data included solar radiation, wet and dry bulb temperature, relative humidity, hydrothermograph readings, wind velocity and direction as well as temperature of the drying material. A mathematical model, adaptable to the computer, has also been developed which will hopefully predict solar drying rates under a variety of weather data. Weather data taken during the drying trials have been prepared for computer analysis and the model will be compared to actual test results.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

1.0029,
BIOLOGICAL ACTIVATION OF MOLECULAR HYDROGEN - STUDIES ON ENHANCEMENT AND STABILIZATION OF HYDROGENASES

M.D. Kamen, University of California, San Diego Campus, Graduate School, Dept. of Chemistry, *P.O. Box 109, La Jolla, California* 92037 (INT77-23755)
This award provides travel support for Professors Martin Kamen and Nathan Kaplan of the University of California, San Diego, for cooperative research in hydrogenases with Professor T. Horio, Dr. T. Kakuno and their associates, Institute for Protein Research, Osaka University, Japan. The joint studies will involve: (1) a general survey of microorganisms, extended to include marine forms, and thereby acquire a greater range of occurrence of hydrogenases than now available; (2) genetic manipulation to improve yields of stable hydrogenases from such sources as well as those now known; and (3) systematic investigation of media for immobilization and study of interactions of such media during and after binding with adequately purified and characterized hydrogenase systems. The work of characterization of several hydrogenases (those from Cl. pasteurianum, Cl. kluyveri and C. vinosum) and ferredoxins will be divided between the U.S. and Japanese groups. The eventual objective is to clarify structural bases for hydrogenase activity. This project may have application in allowing development of the technologies for bioconversion of water to hydrogen by solar energy. The collaboration has been approved under the U.S.-Japan Cooperative Science Program and the work of Japanese investigators will be supported by the Japan Society for the Promotion of Science.
SUPPORTED BY U.S. National Science Foundation, Directorate for Scientific Technological & Internat. Affairs, Div. of International Programs

1.0030,
SOLAR HEATING AND COOLING DEMONSTRATION POND PROJECT

Unknown, Adams-Arapahoe School, *Aurora, Colorado* 80011 (EG-77-A-03-1518)
SUPPORTED BY U.S. Dept. of Energy

1.0031,
COLORADO TITLE V RURAL DEVELOPMENT DEMONSTRATION PROJECT

J.T. Newlin, Colorado State University, Agricultural Experiment Station, Dept. of Education, *Fort Collins, Colorado* 80523 (COL04770)
OBJECTIVE: The revitalization of rural areas and rural communities. Assist local directed toward opportunities for people to become stronger and more capable human beings with options as to one's work and one's place of residence with an enhanced capacity to play a part in making decisions affecting one's community.
APPROACH: Facilitate the delivery of resources in support of rural development activities by means of workshops, seminars, conferences, development of information media and documentation of research needs.
PROGRESS: An experiment to determine if attitudes of young people ready to enter the teaching job market could be changed to favor rural communities over urban communities. Results indicated that such a change could in fact occur if the person were subjected to a period of living and teaching in a rural community. (1st Phase) The 2nd Phase of this project will entail a survey of the 100 smallest rural school systems in Colorado to determine rural teacher training needs and to design appropriate training programs. A study of the effectiveness of weatherization modifications (insulation, etc.) performed on a selected group (40 dwellings) of housing units in Fort Morgan, Colorado. Cost savings effected by weatherization treatments were calculated. (Project completed). Data is currently being gathered to evaluate effectiveness of twelve low-cost solar walls built as a demonstration of low-cost solar heating systems in a self-help housing development in Millikin, Colorado. Report is expected to be completed by Spring of '78. A pilot study of groundwater recharge potential in the Frenchman Watershed.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Colorado

1.0032,
EVALUATION OF HIGH QUALITY FORAGE PRODUCED FROM SOLAR ENERGY DRYING SYSTEMS

R.W. Hansen, Colorado State University, School of Engineering, Dept. of Agricultural Engineering, *Fort Collins, Colorado* 80523 (7099-20190-011-A)
OBJECTIVE: Determine the feasibility of using solar energy to dry forage to produce a high quality feed additive.
APPROACH: Three types of forage products, whole alfalfa, alfalfa tops and grass clippings will be processed by field curing conventional high temperature dehydration and solar dehydration to produce nine and end products. These will be evaluated to determine the effect of the treatments on the various cartenoids and xanthophylls. Feeding trials will be conducted to determine the growth response due to the different drying treatments.
PROGRESS: Final Report: A 6.7 m 2 double-glazed flat plate solar energy collector was ducted to a batch-type drum dryer with a capacity of 91 kg batch-type of wet forage. Air flow rate for the system was 4 3/min. Air temperatures ranged from 54 degrees C at noon to 16 degrees C at night. Alfalfa and turf grass clippings dried by this system were compared with suncured and high-temperature dehydrated material. Feeding quality measured chemically showed that the solar dried alfalfa is similar to high temperature dehydrated alfalfa. The lutein was about the same for each, the protein was slightly higher in the solar dried and the carotene was higher for the high-temperature dehydrated alfalfa. The lutein and carotene were both much lower in the sun cured sample. The quality of the turf grass clippings was high for all drying methods. Chick feeding trials indicated that levels up to 10% of the diet can be either the solar dried or dehydrated alfalfa can be fed without affecting the performance of the chicks. For the grass the top limit was also set at 10%. Preliminary economic analysis indicate that the solar collector-dryer system for a 150,000 broiler production unit is close to being economically attractive. The best estimate of costs which included a $312/m 2 collector system yielded an after tax return of 10.6%.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0033,
DEVELOPMENT AND DEMONSTRATION OF SOLAR PROCESS DRYING OF POTATO PRODUCTS

C.C. Smith, Colorado State University, School of Engineering, Dept. of Civil Engineering, *Fort Collins, Colorado* 80523 (7091-20510-007A(1))
OBJECTIVE: Determine suitability of solar process drying for vegetables, textured vegetable protein and potatoes. Establish solar process drying methods necessary to maintain high quality in potatoes and other foods.
APPROACH: Develop solar drying conditions necessary to dry products while retaining high quality. Determine high temperature, rapid drying rate conditions needed in operational potato drying plant, augmenting second and third stage, lower drying rates with solar heated air or water. Develop potato drying processes maximizing second stage drying which can be operated with solar radiation from the highest radiation period of the day, accumulating products after that stage for further finish drying as necessary. Determine bacteria counts and other quality factors to study effects of drying conditions on product quality.
PROGRESS: Experiments have been carried out on a hot-air bin dryer for diced potatoes to simulate intermediate or finish drying of potatoes in a continuous drying system, for those stages which would be most compatible with solar drying. Using solar heated air, satisfactory results have been obtained with relatively low moisture levels (7.6-13.5%) and drying times from 6 to 12 hours, producing products with satisfactory color and vitamin content. Preliminary treatments with sodium bisulfite with or without steam blanching, reduced enzymic browning effects. Blanching leached out reducing sugars and other chemicals responsible for off-colors and flavors, and resulted in product improvement. Recommendations were developed for using solar heated air for augmentation of the intermediate and finish drying operations in a continuous commercial potato dryer.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0034,

EXPERIMENTAL INVESTIGATION OF THE TROMBE WALL PASSIVE SOLAR ENERGY SYSTEM

Unknown, Energy Engineering Group Inc., *Idaho Springs, Colorado* 80452 (EG-77-G-04-4145)

DOE Project to investigate the thermal balances and thermal circulation in a Trombe wall passive solar collection system using an experimental test building equipped with velocity probes, thermocouples, and pyranometer. Free convection heat transfer and fluid mechanics will be studied in the wall unit using a variable gap geometry between the masonry wall and the glazing cover unit. Energy balances on the test building will be performed for varying time periods. Privately funded research has been conducted to investigate the technical and economical feasibility of auxiliary, off-peak electrical energy storage for both solar and non-solar heating systems. Study parameters included design weather scenarios, annual electric rate increases, building space heating loads, solar storage capacity, utility rate structure, auxiliary (non-solar) storage capacity, load control strategy, solar collector type, solar collector area, collector thermal performance and costs. Privately funded research has been performed on the feasibility of wind powered electric generation plants for single residences and clusters of residences.

SUPPORTED BY U.S. Dept. of Energy

1.0035,

THE USE OF A CONCENTRATING SOLAR COLLECTOR FOR HEATING AND COOLING OF BROILER HOUSES

N.E. Collins, University of Delaware, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Newark, Delaware* 19711 (7004-20400-016-A)

OBJECTIVE: Construct and operate a prototype solar heating system for broiler houses utilizing a cylindrical, line-concentrating, pressure-stabilized solar collector and investigate the economic feasibility of solar cooling during the summer months.

APPROACH: Retrofit broiler house for limited area brooding; install solar and data collection system; obtain data from chick traits; use computer simulation to refine system and to study summer cooling.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Atlantic Area

1.0036,

LOW COST SOLAR COLLECTION AND STORAGE SYSTEM FOR SUPPLEMENTAL HEATING OF BROILER HOUSES

N.E. Collins, University of Delaware, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Newark, Delaware* 19711 (DEL00187)

OBJECTIVE: Determine performance of horizontal plastic solar collectors using water as the collecting and storage medium. Develop computer simulation to optimize the utilization of solar heating and evaluate a pilot model.

APPROACH: Flat tube collectors and storage ponds of varying sizes and amounts of insulation will be evaluated for efficiency as heat collectors. Data to be recorded will include solar radiation (measured with Fritschen net radiometer), ambient air dry bulb and dew point temperatures, collector temperatures and the temperature gradient below the collector. All temperature data will be measured and recorded on magnetic tape by a 40 channel thermocouple reporting system. The computer simulation will consider the available solar radiation, collector and storage design, sizes, efficiencies, cost and predicted supplemental heating load. A prototype of the optimum solar heating system for a broiler house will be constructed and tested to verify the computer simulation for field applications.

PROGRESS: The emphasis continues to be on the development of a computer simulation of on-farm broiler production. To improve model accuracy, revisions were made in the description of 1) heat load, 2) water spillage, 3) brooder stove operation and 4) solar system performance. In cooperation with Delmarva Poultry Industry, Inc., procedures were incorporated in the model to determine fan operating time and the cost of electrical power. As part of the program, a physiological model of the broiler is being developed. This model has identified heat stress as the cause of mortality during a power failure. As an alternative to flat plate collectors, a cylindrical, line-concentrating, pressure-stabilized solar collector was built and tested. Using a N-S orientation, a collector efficiency of 65% was obtained during the summer. Water temperature was increased from 80 to 210 degrees F when the flow rate was 0.03 gpm. The collector had a projected area of 14 sq. ft., an aluminized mylar surface and a manual tracking system. An automatic tracking system is now being tested. To be economically feasible, the simulation indicates that the collector cost should not exceed $2.50 per sq. ft. and the storage must be constructed for about $1.00 per cu. ft. of water stored.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Delaware

1.0037,

AGRICULTURAL ENGINEERING SERVICES

E.N. Scarborough, University of Delaware, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Newark, Delaware* 19711 (DEL00645-A)

OBJECTIVE: Provide advice and perform construction services to science and economics departments in the Experiment Station as an aid to their research program.

APPROACH: Specific items of research equipment are constructed or modified according to the needs of the researchers. This is done on a work-order basis within the limitations of available personnel and equipment for such service.

PROGRESS: The work for the year consisted of the design, construction and/or maintenance of equipment for research, teaching and extension activities of the College of Agricultural Sciences. One hundred twenty-four work orders were processed. Major work orders processed included the assembly and calibration of 100 rain gages, construction of drive train for a concentrating solar collector, construction of solar sensing device and the preparation of the specifications for the planned addition to the Georgetown substation office complex.

SUPPORTED BY Delaware State Government

1.0038,

SOLAR HEATING AND COOLING SYSTEMS

R.A Buthmann, General Electric Co., Center for Energy Systems, *777 14th St. N.W., Washington, District of Columbia* 20005

Numerous solar related technology research and development including wind power, photovoltaic, solar energy, and solar heating and cooling.

SUPPORTED BY U.S. Dept. of Energy

1.0039,

TECHNOLOGY ASSESSMENT OF SOLAR ENERGY STUDIES

A.B. Cambel, George Washington University, School of Engineering & Applied Sciences, Dept. of Civil Mechanical & Env Engin, *725 23rd St. N.W., Washington, District of Columbia* 20037 (EG-77-G-01-4040)

The objectives of this study are to prepare an assessment of on site solar energy systems: space heating, space cooling, water heating, photovoltaics, wind energy conversion, fuelwood and peripheral solar thermal, that may be utilized by ERDA(DOE) and the intelligent layperson. To incorporate in this assessment the advice and counsel of previous authors of solar energy technology assessments and a select Peer Group of specialists in on site solar energy systems is also included as an objective in the study. This project has subcontracts.

SUPPORTED BY U.S. Dept. of Energy

1.0040,

ENERGY USE IN MARKETING AND PROCESSING FOOD AND FIBER COMMODITIES

B.L. French, U.S. Dept. of Agriculture, Economics & Statistics Service, Commodity Economics Div., Poultry Products Program Area, *14th & Independence Ave. S.W., Washington, District of Columbia* 20250 (CE-08-077-11-00)

OBJECTIVE: Develop estimates of energy required in marketing food and fiber commodities, present and future. Conceptualize and develop analytical models for aggregating and disaggregating energy data and studying alternatives relating to energy forms, locational, geographical and seasonal problems, commodity shifts, and long-range programs. Analyze potential energy use with alternative marketing methods, new technology, and conservation practices. Determine effects of modification of regulations on energy use by agricultural marketing firms and of national and international energy policies on costs, prices, location of production and marketing functions, and commodity mix. Suggest policy alternatives which would maintain a viable agriculture.

APPROACH: Develop estimates of energy use in the marketing of selected food and fiber commodities. Conceptualize and test an accounting model for measuring energy use in agricultural marketing and evaluate potential energy requirements with alternative marketing systems. Estimate State energy requirements for marketing by type of energy, season, commodity and function. Study effects of modified transportation and environmental regulations. Develop structural profiles of agricultural marketing firms with inputs and cost measurements.

PROGRESS: Available energy data and studies were reviewed. Schedules and plans for survey of energy use, conservation, and practices in marketing all food and fiber commodities were completed and analysis was begun. A framework for marketing energy data base was developed. A report on energy use and costs in Southern broiler processing plants was published. Data on energy use and costs in rendering poultry products was analyzed and a report was published on solar grain drying systems.

SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Commodity Economics Div.

1.0041,

SOLICITATION, SELECTION, AND AWARD OF GRANTS OR CONTRACTS OF RESIDENTIAL SOLAR HEATING AND HOTWATER HEATING DEMONSTRATION PROJECTS (ABBREV)

Unknown, U.S. Dept. of Housing & Urban Development, Program Development, *451 7th St. S.W., Washington, District of Columbia* 20410 (EX-76-A-29-1020-003)

SUPPORTED BY U.S. Dept. of Energy

1.0042,

MONITOR SYSTEMS SELECTED FOR THE RESIDENTIAL DEMONSTRATION PROGRAM TO DETERMINE WHETHER SELECTED SOLAR SYSTEMS MEET CRITERIA (ABBREV)

Unknown, U.S. Dept. of Housing & Urban Development, *451 7th St. S.W., Washington, District of Columbia* 20410 (EX-76-A-29-1020-008)

SUPPORTED BY U.S. Dept. of Energy

1.0043,

PROBLEMS & SOLUTIONS IN ADAPTING SOLAR ENERGY TO RESIDENCES - CONSULTANT SERVICES (ABBREV)

Unknown, U.S. Dept. of Housing & Urban Development, *451 7th St. S.W., Washington, District of Columbia* 20410 (EX-76-A-29-1020-009)

SUPPORTED BY U.S. Dept. of Energy

1.0044,

ANALYSIS OF INCORPORATING PURCHASES OF RESIDENTIAL SOLAR ENERGY EQUIPMENT INTO THE INDUSTRIAL FORMS OF MORTGAGE FINANCING (ABBREV)

Unknown, U.S. Dept. of Housing & Urban Development, *451 7th St. S.W., Washington, District of Columbia* 20410 (EX-76-A-29-1020-010)

SUPPORTED BY U.S. Dept. of Energy

1.0045,

SOLAR DEMONSTRATION PROJECT - WILDLIFE REFUGE

Unknown, U.S. Dept. of the Interior, Fish & Wildlife Service, *10th & Constitution Ave. N.W., Room 378, Washington, District of Columbia* 20560 (EG-77-A-29-1103)

SUPPORTED BY U.S. Dept. of Energy

1.0046,

SOLAR ENERGY CONVERSION AS APPLIED TO GREENHOUSES

W.E. Waters, Agricultural Research & Education Center, *Bradenton, Florida* 33505 (FLA-GC-01793)

OBJECTIVE: Design, construct and install a practical, moderate temperature solar energy conversion device to heat air; couple this device with heat storage systems suitable for greenhouse application; offer results of this research to the general public with emphasis on attracting manufacturers willing to construct such systems for greenhouse industry.

APPROACH: Construct varying quantities of each collector design (3 designs); construct inexpensive rock storage containers of varying designs; design, install these devices and a ducting and control system in a glass greenhouse at the Bradenton Agricultural Research Center; incorporate testing devices in said greenhouses to refine operation and equipment design.

PROGRESS: Research studies into the methods of applying solar energy to space heating of greenhouses were continued with some advancements in the following areas: (1) evaluation of a solar rock-storage heating system incorporating an under bench rock-storage, with the collector constructed by placing a clear plastic ceiling in the greenhouse to form an attic and using shade cloth as the collector plate; (2) design, installation and evaluation of an underbench water storage/heat exchanger with a poly collector; (3) evaluation of certain foliage and flowering plant growth in the reduced light environment created by the attic-type solar collector. Research on energy efficient greenhouse design was continued with the construction and limited evaluation of three types of ridge and gutter naturally cooled greenhouses at AREC-Bradenton.
SUPPORTED BY Florida State Government

1.0047,
SURFACE DRYING CITRUS WITH SOLAR REGENERATED DESICCANTS
W.M. Miller, Agricultural Research & Education Center, *P.O. Box 1088, Lake Alfred, Florida* 33850 (7096-20510-014-A)
OBJECTIVE: Determine design information for fruit drying based on desiccant and solar regeneration. Design, construct and evaluate pilot system. Determine best desiccants based on regeneration, water capacities, adsorption rates and cost. Develop plans for large-scale solar regenerative dryer.
APPROACH: Survey desiccant drying techniques and direct solar regeneration systems. Design regenerative collector and fabricate. Study comparative features, e.g., single vs. double glass, natural vs. forced air, rate of desiccant flow, equilibrium moisture content at different temperatures and desorption rates as a function of these parameters. Optimum operating conditions to establish most feasible desiccants will be determined. Recommended designs and criteria will be developed for a prototype desiccant regenerative fruit dryer.
PROGRESS: Solid desiccants where moisture holding mechanism is surface adsorption, were found signficantly regenerated at 50 to 100 degrees C. This was demonstrated with alumina and silica gel. Direct regeneration of both was demonstrated using flat plate collectors with single glass cover and tray inserts, and proved to be feasible. Typically, the silica gel moisture level was reduced from 30.0 to 8.0% and activated alumina from 12.8 to 2.2% after 2-day exposure to the sun. Use of thin bed filters for drying desiccants provided sufficient drying potential for surface moisture drying of citrus in a 2-4 minute range. Humidity ratio differences were obtained as follows: silica gel -initial 0%, to 0.010 kg/kg; activated alumina - initial 4%, to 0.004 kg/kg. Feasibility of regenerable desiccant materials for surface drying of oranges is high enough to warrant further study and design of a pilot system.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0048,
DESICCANT DRYING AND SOLAR ENERGY REGENERATION FOR FRUIT AND VEGETABLE DRYING
W.M. Miller, Agricultural Research & Education Center, *P.O. Box 1088, Lake Alfred, Florida* 33850 (FLA-CS-01909)
OBJECTIVE: Determine and collect the required design information for fruit drying based on desiccant water removal and solar regeneration of the desiccant. Design, construct and evaluate a pilot plant fruit drying system based on desiccant dehumidification of ambient air. Design, construct and evaluate a dessiccant solar regeneration system compatible with fruit dryer requirements. Design and construct a demonstration system integrating both desiccant dehumidification and solar regeneration of the desiccant.
APPROACH: Determine feasibility of desiccant drying/solar energy regeneration as an energy alternative in fruit and vegetable surface moisture drying. Develop and design pilot plant equipment for evaluating both desiccant drying and solar desiccant drying regeneration. Fabricate a pilot system to demonstrate proof of concept for utilization in citrus and other fruit and vegetable operations.
PROGRESS: Required drying potential for surface moisture evaporation was established for 4 citrus varieties. The drying potential, expressed as humidity ratio difference (HRD), ranged from 0.008 to 0.015 G/G with drying time varying from 2 to 3 min. A correlation between HRD and drying time was established. Air recycling appreciably reduced the energy requirement. Initial tests were conducted to establish the feasibility of chemical dehumidification for creating a drying potential. Batch tests with silica gel and activated alumina indicated that peak HRD levels of 0.0085 to 0.010 G/G were attainable for a thin-bed approach. A pilot plant citrus dryer was fabricated to utilize the solid desiccants for surface moisture drying.
SUPPORTED BY Florida State Government

1.0049,
ESTABLISHMENT OF A CONSUMER PROTECTION SOLAR COORDINATION COMMITTEE (CPSCC)
D.L. Block, State University System of Florida, University of Central Florida, School of Engineering, Dept. of Civil Engineering & Environmental Sciences, *P.O. Box 25000, Orlando, Florida* 32816 (10-1056-014)
To promote and plan for the establishment of a voluntary framework of state and local public agencies that are now conducting, or contemplating conducting, programs aimed at protecting consumers through such programs as the testing and certification of solar equipment, a Consumer Protection Solar Coordination Committee (CPSCC) will be established. The Committee's general objective will be to determine the most feasible means for providing a national forum of public agencies concerned with this subject area under a voluntary framework. The prime function of this mechanism will be to provide for the exchange of information, coordination of programs, development of uniform criteria, and establishment of consensus or reciprocal agreements whenever possible among the participants.
SUPPORTED BY U.S. Dept. of Energy, Office of Solar Applications & Commercialization

1.0050,
IMPROVED UTILIZATION OF SOLAR ENERGY ON TROPICAL FARMS
C.D. Baird, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (7002-20518-001-A)
OBJECTIVE: To upgrade technical base for use of solar energy in rural areas of the tropics. To develop and effective energy conversion package capable of meeting the basic needs for home food processing and preparation.
APPROACH: Develop and extend data base on solar energy potentials in selected tropical areas. Examine energy uses on farms and in rural villages to identify critical uses for food processing and preparation. Develop simple system to satisfy identified needs. Test system in the laboratory and on site to verify effectiveness.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0051,
SOLAR GREENHOUSE HEATING AND COOLING
C.D. Baird, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-01793)
OBJECTIVE: Develop and evaluate solar heating and cooling systems for greenhouses.
APPROACH: Modify existing greenhouses at Brandenton AREC to accommodate solar heating components. Emphasis will be placed on assembling a complete system as soon as possible in order to obtain data on the overall performance of the system, including the interactions between the solar collectors, thermal storage, and heat exchangers. Systems using water as the heat transfer and storage medium will be compared with systems utilizing air and rock storage.
PROGRESS: Rising fuel costs and uncertainty of fuel supply continue to plague greenhouse operations. Since solar greenhouse heating systems constructed from conventional components are not economically feasible, work on low-cost components and the integration of solar heating components into the basic greenhouse structure is being conducted. Two basic types of solar heating systems are being considered; one using water as the working fluid and the storage medium, and the other using air as the transfer fluid and rock for storage. The water system was low-cost plastic collectors and combinatioin heat exchanger/storage tank placed under the plant support benches. The air system utilizes a rock bed under the plant support benches and a suspended screen in the attic of the greenhouse for the solar collector. Standard shade cloth (25%-50%) is used as the heat absorber and is sealed off from the plant growth area by clear poly. This type system can be used only for crops that can tolerate significant light reduction, such as ornamental foliage plants. Placing the shade cloth on movable supports and closing only during periods of high light intensity may extend its application to crops requiring more light. The air/rock system has a pay back period of about 500 days for the southeast. A computer program has been developed for designing thermal storage rock beds.
SUPPORTED BY Florida State Government

1.0052,
GRAIN DRYING WITH SOLAR ENERGY IN THE HUMID SOUTH
C.D. Baird, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-01852)
OBJECTIVE: Develop and evaluate grain solar drying systems.
APPROACH: Construct plastic solar collectors and conduct corn and soybean drying tests using two 100-bushel metal bins. Various air flow rates will be used. The tests wil include drying experiments during the daytime hours only, drying experiments with the blowers run all day and all night, and experiments with the blowers on a humidistate setting at night. Temperatures throughout the collector, temperature profiles in the grain bins as well as the relative humidity, ambiant temperature, insolation will be monitored and recorded by a data acquisition system.
PROGRESS: The purpose of this research project is to find the most appropriate methods of applying solar energy to grain drying in the Southeast. Research thus far has concentrated on low-cost plastic solar collectors connected to conventional grain storage bins. Based on experimental results to date, the following conclusions can be drawn: (1) It is technically feasible to dry grain with solar energy under conditions of high humidity and high temperatures in the Southeast, however, drying has to be done within a few days to a week in order to prevent spoilage. If the grain harvest is free from aflatoxin at harvest, it appears that the grain will remain aflatoxin-free after solar drying if drying time is a week or less. (2) Solar grain drying is still not economical (considering all costs) when compared to the present cost of fuel and based on a 60 day drying season. The unit cost for solar heat is about twice that of conventional fuels. Other uses of the solar heating system to allow the collection of more solar energy per year could make the system economically feasible at today's fuel prices. (3) A suspended plastic screen collector costs less than 50cents/ft 2 (material costs, not counting labor) and has an efficiency of 30-45% (25-45 degrees F temperature rise). (4) A collector with two suspended plastic screens is significantly more efficient (20-25% more efficient) than a similar collector with just one screen.
SUPPORTED BY Florida State Government

1.0053,
DESICCANT DRYING AND SOLAR ENERGY REGENERATION FOR FRUIT AND VEGETABLE DRYING
E.K. Bowman, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-01909)
OBJECTIVE: Develop elemental cost data covering: Desiccant materials; equipment design approaches and features. Develop appropriate rates and relationships as basis for input requirements. Carry out analytical work and develop cost relationships for selected component and system alternatives. Express results in terms appropriate for industry use.
APPROACH: Established engineering/economic techniques will be used in all steps of cost investigation. Both ownership and operating requirements will be considered in cost projections. Alternative components and systems considered in evaluation, will be selected in the light of experimental performance and potential.
PROGRESS: Initial work was done to assemble data for development of cost relationships for the experimental method and conventional drying method. Approach involves use of commercial equipment-maker costs as basis for some components combined with costs for other components projected from their construction for research. Calculated costs figures reflecting percent moisture adsorption and cost per pound of desiccant material indicated activated alumina and silica gel to be preferable costwise to other

desiccant materials suitable for consideration. Both materials are rated for unlimited number of regeneration cycles.
SUPPORTED BY Florida State Government

1.0054,
SIMULATION MODELS OF TRANSIENT ENERGY REQUIREMENTS TO HEAT/COOL RESIDENTIAL BUILDINGS
D.E. Buffington, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-01702)
OBJECTIVE: Develop computer simulation models of the energy requirements to heat/cool residential buildings. Evaluate by models the influence of a wide array of construction materials and operational practices of heating/cooling systems upon energy requirements for heating/cooling residential buildings. Develop and publish recommendations (in engineering design language as well as layman's language) of effective means to reduce energy requirements to heat/cool new and existing residential buildings.
APPROACH: Develop a computer simulation model of the transient energy requirements for heating and cooling residential buildings. Then generate the simulated energy requirements of residential buildings based on many different designs for construction and operating practices. Based on the computer output, develop recommendations to reduce energy requirements for heating and cooling.
PROGRESS: The effectiveness of various: (1) shading levels on walls and roofs; (2) exterior colors of walls and roof; and (3) building orientations for conserving energy in comfort conditioning residential buildings was evaluated with simulation models. The computer simulation results showed that a typical Florida residence having walls and roof 2/3 shaded, light-colored walls and roof, and east-west orientation has an average heat extraction rate 27% less than the same building with no shade on dark-colored walls and roof with a north-south orientation for the summer design-day in Orlando, Florida. The computer simulation results were summarized by comparing the energy requirements for cooling and heating a specified 'low energy' and 'high energy' house. The 'high energy' house was common construction, while the 'low energy' house was one designed, constructed, and operated with energy conservation in mind. The heat extraction rate of the 'low energy' house was 67% less than the 'high energy' house; the heat addition rate for the winter design-day was 70% less in the 'low energy' than the 'high energy' house. The effects of solar radiation and wind velocity on the heat gains and losses of an agricultural structure were simulated for four different orientations in seven different U.S. climatic regions.
SUPPORTED BY Florida State Government

1.0055,
DRYING SEAFOOD PRODUCTS WITH SOLAR ENERGY
J.C. Deng, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Food Science & Human Nutrition, *Gainesville, Florida* 32601 (7092-20530-002-A)
OBJECTIVE: Develop and study low cost solar dryers for drying seafood and mullet roe. Develop optimum conditions and study effects of collector material and configuration, radiation rate, air flow, on quality of products. Determine need for heat storage and potential energy savings.
APPROACH: Develop dryers designed of simple, inexpensive materials to use direct solar radiation and solar heated air (indirect). Compare natural convection with forced air. Prepare dried mullet roe, minced fish cake and fish fillets (white and dark flesh). Compare drying of fresh fish and roe, with products previously cured with salt. Compare temparatures and air velocities vs. quality of products. Develop optimum conditions for retention of quality and basic information for developing design and drying system for commercialization.
PROGRESS: A wooden rectangular cabinet with transparent fiberglass cover was constructed for drying fish cakes and fillets. Satisfactory dried products were prepared in 2-4 days of solar drying. Side air flow patterns gave better results than top to bottom air flow and two distinct drying steps were observed, based on moisture content. The first day, fish dried following constant rate kinetics decreasing to 60% moisture, following which falling rate kinetics were observed. Direct insolation units dried mullet roe in less time due to higher temperatures. Product temperature maximum of 160 degrees F was reached, although product temperatures were 130 degrees-140 degrees F. Under some conditions, excessive browning made the dried roe unacceptable in quality. In forced air dryers, using solar heated air, drying rates ofr mullet roe were similar to direct dryers, and product color was improved. However, mold growth was worse. Preliminary treatments are being developed to avoid mold growth. A solar assisted fish smoker was used for preparing smoked mullet fillets. Temperature increases of 64 degrees F over ambient were the highest achieved however, which led to maximum collector temperatures of 129 degrees F. For satisfactory product, exposure to 180 degrees F for 30 minutes has been required as minimum. Thus, improvements in collector design to allow more air stagnation, and increased temperature will be required.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0056,
PRELIMINARY AGRICULTURAL ENGINEERING RESEARCH
G.L. Zachariah, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-00001)
OBJECTIVE: Conduct preliminary research on agricultural engineering problems.
APPROACH: Exploratory experiments are to be conducted to obtain information for detailed research planning and in preparation of project outlines.
PROGRESS: The technologic and economic feasibility of converting sugarcane production residues to utilizable energy forms is being investigated for waterwall incineration, anaerobic digestion and pyrolysis. Modeling studies have been initiated of biological and ecological systems in association with plant physiology and growth, algae production using animal waste as nutrient medium, and renovation properties of overland flow irrigation systems using high strength organic waste. Production and processing of algae for animal feed appears promising. Algae ponds with swine waste as the nutrient medium have produced several hundred pounds of feed material for animal nutrition studies. Progress is being made in use of micro-processors for remote data acquisition systems. Modeling and analysis techniques are being applied in an integrated pest management system for celery production. The subsurface drainage study for potatoes at Hastings has demonstrated techniques for increasing production and is being expanded. The infrared radiation onion curing system has been tested further and still looks promising. The potential of solar drying of grain sorghum with a low-cost plastic collector is being investigated. Studies of drip irrigation for citrus is continuing and results still appear promising.
SUPPORTED BY Florida State Government

1.0057,
DRYING SEAFOOD PRODUCTS WITH SOLAR ENERGY
C.D. Baird, State University System of Florida, University of Florida, School of Agriculture, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-01990)
OBJECTIVES: Develop and study low-cost solar driers that can be used to dry seafood and mullet roe in Florida and southern states: optimize solar seafood drying process and investigate the parameters that will affect product quality such as collector material and configuration, radiation rate, air flow rate, drying temperature and humidity; investigate the need for heat storage for use at night and during cloudy periods based on product quality and economic feasibility; investigate the efficiency and potential energy saving of different solar fish drying systems.
APPROACH: In addition to mullet roe, two types of fish products will be dried, one is minced fish flesh made from sheepshead, primarily white flesh, the other is fish fillets made from mullet consisting of white and dark flesh. Two types of solar dryers will be tested. One is a cabinet-type using direct heating of the product with convection air flow for moisture removal. The other is a tray-type with forced convection drying using solar heated air. The latter dryer will be equipped with collectors that are efficient and economically feasible. Different processing parameters will be investigated in order to obtain optimum conditions for processing the dry seafood products with a high quality and processing costs that are not excessive.
SUPPORTED BY Florida State Government

1.0058,
IMPROVED FISH SMOKING WITH A COMBINED SOLAR DRYER AND SMOKER
J.C. Deng, State University System of Florida, University of Florida, School of Agriculture, Dept. of Food Science, *Gainesville, Florida* 32601 (R/FR-12)
OBJECTIVES: 1. To develop a combined process of solar drying and smoking which can produce an acceptable smoked fish product following FDA's Good Manufacturing Practice. 2. To study factors affecting product quality during processing and storage. 3. To investigate the economical feasibility of the combined process.
ANTICIPATED BENEFITS: It is expected that the obtained results will provide Florida fish smoking processors and improved smoking process which not only produces high quality smoked fish, but also is economic. The pertinent information will be introduced to the seafood industry through direct consultation or presentation in seminars, workshops, demonstrations and/or conferences assisted by the Marine Advisory Program.
SUPPORTED BY U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin., Sea Grant Office

1.0059,
SOLAR ENERGY UTILIZATION FOR TROPICAL FARMS
E.A. Farber, State University System of Florida, University of Florida, School of Engineering, Dept. of Mechanical Engineering/Agricultural Engineering, *220 Black Hall, Gainesville, Florida* 32611 (FLA-AG-01967)
OBJECTIVES: Upgrade technical base in rural and farming areas of the world using alternative energy; selection of energy conversion system capable of converting solar energy to meet the assessed need. Build and test the developed system. Install system on site.
SUPPORTED BY Florida State Government

1.0060,
DEHYDRATION OF SOUTHEASTERN FRUITS AND VEGETABLES BY SOLAR ENERGY
R.E. Berry, U.S. Dept. of Agriculture, Agricultural Research, *P.O. Box 1909, Winter Haven, Florida* 33880 (7608-20510-013)
OBJECTIVE: Develop practical dehydration process for food and agricultural products using solar energy augmented by fossil energy sources when necessary, to develop new dehydrated fruit and vegetable products.
APPROACH: Survey previous work, design and construct batch-type solar dehydrator, test dehydrator on traditionally dried as well as unique tropical and subtropical fruits and vegetables; assess and select food products most compatible with this type dehydration. Develop combination dryers with flexibility of diverting between solar and conventional energy sources. Design for optimum commercial application. Test flavor quality, storage stability of fruit and vegetable products.
PROGRESS: A small solar dryer has been constructed with two drying compartments, using screen trays about 1 meter 2 each. Product is dried by direct exposure to the sun, with heat augmented by reflected radiation from above and below and moisture transferred by forced air flow. Using this dryer data have been obtained for drying rates for carrots, celery, green peppers, parsley, peaches, and mushrooms. Commercially available inexpensive solar cells were modified for use in monitoring solar radiation to the dryer. Treatments with bisulfite and hyposhlorite solutions were developed for green peppers, peaches, nectarines, to avoid nonenzymic browning and darkening during drying. Mangos were very satisfactory with little pretreatment. Storage studies on solar and conventional hot air dried green peppers showed no significant differences in vitamin C retention. Solar dried mushrooms had much higher bacterial counts than commercial products even after hypochlorite dip. More work is needed to develop sanitation conditions for satisfactory solar dried mushroom products. Commercial interest has been indicated for solar dried mushrooms.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0061,

PRODUCTION OF HYDROGEN BY MARINE BLUE-GREEN ALGAE

A. Mitsui, University of Miami, D.H. & Lewis Rosenstiel School of Marine & Atmospheric Sci., Dept. of Biology & Living Resources, *4600 Rickenbacker Cswy., Coral Gables, Florida* 33149 (PFR77-11545 A01)

This award provides for incremental funding for the NSF Continuing Grant AER 77-11545 whose objectives are to characterize promising species of marine, blue-green algae which produce hydrogen gas and to optimize this biological activity in these microbes by environmental (physiological) means. Research for this period focuses on determining the nature of the hydrogen donor and in stabilizing and enhancing hydrogen production in the algae.

SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Problem Focused Research

1.0062,

DESIGN OF COLLECTORS AND INSTRUMENTATION FOR SOLAR DRYING OF AGRICULTURAL CROPS

A.P. Sheppard, Georgia Inst. of Technology, Graduate School, *225 North Ave. N.W., Atlanta, Georgia* 30332 (12-14-7001-566)

The project objectives are to design, fabricate and furnish plans on units for field evaluation of several different configurations of improved solar collectors for agricultural dryers specifically oriented toward reducing the fossil fuel consumption for drying peanuts, tobacco, and forage. The initial thrust of the research will be on collector systems which heat the air directly. Secondary effort will be expended on circulating liquid collectors. Various configurations which will improve the heat transfer processes will be evaluated and the most promising incorporated into systems. Since 24 hour drying is normally required, various types of storage will be evaluated for capacity, cost and physical suitability. Instrumentation which will make the data collected by various researchers on solar drying useful will be designed into data collecting systems. Tests conducted on the transmissivity of various glazing materials showed that cellulose acetate butyrate and cellulose acetate propionate may be very well adapted to this use. A prototype rock absorption and storage collector system was constructed and tested. In this absorber, the rock surface is painted black, to increase absorptivity. Very low air velocities are used to pull the heat down into the storage bed. Six prototype solar ponds have been constructed and evaluated. The most promising unit consists of a sealed plastic bag, with a clear top and black bottom, filled with water. In addition to the clear top, a second glazing over the bag is fiberglass. An inexpensive data collection system which scans eight inputs and writes the data on an inexpensive analog recorder has been developed.

SUPPORTED BY U.S. Dept. of Energy

1.0063,

CONTROL SYSTEMS FOR INTERFACING SOLAR AND BIOMASS FUELS IN AGRICULTURAL DRYERS

A.P. Sheppard, Georgia Inst. of Technology, Graduate School, *225 North Ave. N.W., Atlanta, Georgia* 30332 (7007-20190-019-A)

OBJECTIVE: Design, construct and test a control unit to interface solar and biomass fuels in crop dryers.

APPROACH: Information on currently available control systems for the burning of alcohol and methane will be gathered and an economic analysis will be made. The analysis will include the relative merits of electronic and pilot light ignition in addition to costs. Based on this information of prototype system will be designed, constructed and evaluated. The feasibility of using a microprocessor to determine the usage of the back-up system, based on such data as air humidity, temperature, solar radiation, and time of day, will be determined. Close liason with other researchers in solar crop drying will be maintained.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0064,

DEVELOPMENT OF EQUIPMENT AND PROCEDURES FOR IMPROVED HARVESTING AND PROCESSING SOUTHEASTERN FORAGES

J.L. Butler, U.S. Dept. of Agriculture, Agricultural Research, Georgia Coastal Plain Experiment Station, Harvesting & Processing Research, *Tifton, Georgia* 31794 (7702-20190-003)

OBJECTIVE: Develop improved equipment and procedures for producing, harvesting, processing and storing southeastern forage crops which will reduce the cost and energy requirement and enhance the nutritive quality.

APPROACH: Different machines and methods will be developed which will result in increased stand, with minimum disturbance to the sod, of seasonal annual forage crops overseeded on perennial sod crops. New machanisms will be developed to cut and prepare forage crops for field wilting. These will position the forage crop to take maximum advantage of solar, wind and other sources of energy. Processing and storage methods will be evaluated on the basis of energy requirements and effectiveness in converting forage into meat and milk. This work will be cooperative with plant and animal scientists, both state and federal.

PROGRESS: Arrowleaf clover was ensiled with and without the addition of a mixture of propionic acid and formaldehyde (Chemstor III) at the rate of 1.1 percent of dry matter. The treated silage had lower fermentation temperatures and no seepage. Dairy heifers fed the treated silage consumned four percent more silage dry matter per day, gained 20% more per day and ate only 87% as much feed per pound of gain as those fed untreated silage. Monesin sodium was pelleted with Coastal bermudagrass at the rate of 33 m ppm using a specially designed additive hopper. Calves fed the additive gained 12% faster (p less than .05) than the control. Arrowleaf clover overseeded on Coastal bermudagrass sod yielded 1.7 tons d.m. clover and 4.2 tons d.m. Coastal bermudagrass per acre. The yield was considered to be reduced by the dry weather.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0065,

LABORATORY AND PILOT-SCALE STUDIES OF FLUIDIZED-BED DRYING FOR CONTROL OF STORED-PRODUCT INSECTS

H.H. Vardell, U.S. Dept. of Agriculture, Agricultural Research, Stored Products Insects Research & Development Lab., *3401 Edwin Ave., Savannah, Georgia* 31405 (7705-20620-044)

OBJECTIVE: Adapt fluidized-bed drying techniques that may include solar-heated air for use as a non-pesticidal means of controlling stored-product insects in grain.

APPROACH: Initially the effects of various drying temperatures and times necessary for the control of insects infesting various grains subjected to fluidized-bed drying will be investigated. Cooperative studies will be conducted with pilot-plant operations to determine the most effective use of fluidized-bed drying techniques for insect control.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0066,

DEVELOP IMPROVED TECHNOLOGY FOR PRODUCTION OF LOW-COST QUALITY FEED PRODUCTS FROM SOUTHERN FORAGES

R.R. Spencer, U.S. Dept. of Agriculture, R.B. Russell Agricultural Research Center, *P.O. Box 5677, Athens, Georgia* 30604 (7902-20520-007)

OBJECTIVE: Develop practical methods of processing Southern forages to conserve energy and increase nutritive value and feed efficiency.

APPROACH: Investigate combination of field wilting and solar dehydration and chemical/physical treatment of Southern forages to reduce cost and improve quality (nutritive value) of the harvested crop. Forages to be investigated will include Coastal bermudagrass and arrowleaf clover. Use an inexpensive solar dehydrator to determine drying rates of the different forages. Obtain data on quality (chemical composition and digestibility) of the forages as related to treatments. Data obtained will provide the basis for maximizing processing Southern forages in least cost computerized feed formulations.

PROGRESS: The digestibility of low quality Coastal bermudagrass (8.5% protein) can be increased by the combination of alkali treatment and the heat produced in the pelleting of the ground forage. Sodium hydroxide levels of 3 and 7% increased the IVDMD of the pelleted products from 37 to 47 and 55%, respectively. Pre-harvest treatment of Coastal bermudagrass was 1, 2, 4 or 8% aqueous formic or acetic acid reduced the standing plants' moisture content by less than 5%. These tests were conducted under extreme dry conditions which may have adversely effected these results. Coastal bermudagrass hay was wilted in the field to approximately 30% moisture and drying completed with air heated by a solar collector. Evaporation efficiency (water removed/heat delivered) was about 35% for loose hay and 23% for baled hay. Overall efficiency (collector plus evaporation efficiency) was 25% for loose hay and 17% for drying bales. However, baled hay produced 1.2 lbs dry hay/day/cubic foot of drier volume compared to only 0.55 lbs from the loose hay. Preliminary trials to determine field dry matter and nutrient losses during production of hay from Coastal bermudagrass have shown dry matter losses of 32% and protein losses of 16%. These losses were determined under poor haying conditions (i.e. rain, and army worm infestation) which adversely effect the results.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Athens Georgia Area

1.0067,

USE OF SOLAR HEATED AIR IN AGRICULTURE

B.D. McLendon, University of Georgia, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Athens, Georgia* 30602 (GEO00529)

OBJECTIVE: Evaluate the characteristics of selected types of air heating solar collectors operating in conjunction with agricultural product drying systems and environmentally modified animal housing and develop guidelines for operation of solar assisted drying systems in the Southeast.

APPROACH: Commercially available and experimental collectors will be tested over various volumetric flow rates and conditions. A prototype drying system will be used to evaluate product drying characteristics a linear system model will be developed for optimizing system components. Solar energy with rock storage of heat supplemented as necessary with electric heat will be used for brooding baby chicks confined for 4-wks to a 1/3-section of a broiler house. Attempts will be made to adapt portions of the system for environmental modifications in swine and calf housing.

PROGRESS: Experimental comparison of energy efficiency, and drying rate of conventional, total solar and solar-assisted grain drying systems was continued. Corn was dried from 20, 27, and 33% to 12% moisture content (wet basis) during three trials. Energy requirements ranged from 8 Kwhr/mue3 M.P. for conventional drying, to 5 Kwhr/mue3 M.P. for solar assisted drying and 2.5 Kwhr/mue3 M.P. for total solar drying with drying rates of 4 to 1.5 to 1 M.P./day, respectively. These tests show that a 50% decrease in non-renewable energy resource can be attained. This assumes a collector area-to-grain volume of 2.1 mue2/mue3 and a drying time increase of four times the conventional rate. Even with low cost collectors, multiple use must be designed into any economically practical energy collection system.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Georgia

1.0068,

USE OF SOLAR HEATED WATER IN AGRICULTURE

B.D. McLendon, University of Georgia, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Athens, Georgia* 30602 (GEO00599)

OBJECTIVE: Optimize the relationship between solar collector size, efficiency, energy storage tank size, capacity of the supplemental heating system and rate of water use for selected systems. Evaluate several methods of using solar assisted water heating systems for underfloor heating of a concrete slab floor in animal housing and greenhouses.

APPROACH: A mathematical analysis of the interrelationships between solar collector size, supplemental energy, system efficiency, storage tank size, and water use rate will be made and the analysis results will be verified experimentally. A mathematical analysis of a floor underheat system will be made and two test sections (a 4'x4' and 4'x8') will be made to evaluate the design equations developed. Using the design procedure developed, a concrete slab underheat system will be incorporated into broiler housing and greenhouses.

PROGRESS: Efficiency measurements on a low cost solar collector that consists of 1.91 cm PVC pipes embedded in a 7.02 cm bed of asphalt paving mate-

nal are being continued. The collector can be constructed for approximately $37 per square meter. Due to the significant thermal lag involved in this collector, all day (as opposed to instantaneous) efficiencies are reported. Under summer and fall conditions, collector efficiency was between 40% and 55% (note: solar isolation measured in the plane of the collector). Wintertime efficiency measurements are currently being made. The solar heated water was transferred to a 3785 liter tank through a low cost heat exchanger. This energy storage system was used in solar grain drying during times when direct solar insolation was not available. This completely replaced the need for direct heating of drying air with a conventional heater. Economic feasibility of the solar system is dependent upon multiple usage of the store energy.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Georgia

1.0069,
NURSERY AND GREENHOUSE MECHANIZATION
B.P. Verma, University of Georgia, Georgia Agricultural Experiment Station, Dept. of Agricultural Engineering, *Experiment, Georgia* 30212 (GEO01201)
OBJECTIVE: Research and develop facilities and equipment for an efficient energy and labor utilization in the production of nursery and greenhouse crops.
APPROACH: Growing areas with controlled traffic pattern will be used in conjunction with a mobile platform. Equipment and facilities will be developed for fertilizing, materials handling, weather protection, etc. Recessed growing areas in the ground with subsurface irrigation and solar heating will be tested to determine if greenhouse could be replaced with such arrangements. A systems analysis of the production systems is also planned.
PROGRESS: Controlled release herbicides using metolachlor and alachlor were field tested. In the best test, over 14 months weed control in containers was obtained with metolachlor controlled release. Laboratory data show that linear release of metolachlor is obtained with each soaking. The multi-level trailer and pallet system was tested in commercial nursery. The palletized system improved the labor output by 38% for potting and loading, by 137% for loading in the field and by 232% for loading trucks for shipping. A computer model is being developed to evaluate several system concepts to further improve materials handling in container nurseries.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Georgia

1.0070,
REDUCING THE COST OF PEANUT HARVESTING, DRYING AND CURING IN THE SOUTHEAST
J.L. Butler, University of Georgia, Georgia Coastal Plain Experiment Station, Dept. of Agricultural Engineering, *Tifton, Georgia* 31794 (0042481)
The project objective is to develop methods and equipment which will reduce the cost of harvesting and curing peanuts by reducing losses and damage and minimizing fossil fuel consumption in drying. New mechanisms will be investigated to harvest peanuts and remove the foreign material, which presently causes problems in handling, drying and storing. The effect of chemicals which alter growth and fruiting habits of peanuts will be evaluated to see whether they can be used advantageously in combination with harvesting equipment to reduce losses, damages or drying requirements. Non-conventional land preparation and planting methods will be evaluated for effects on yield and harvesting efficiency. Various methods of collecting, storing and using solar energy to replace a portion of the fossil fuel energy currently required to dry and cure peanuts will be evaluated. From these studies, recommended equipment, practices and procedures will be developed.
SUPPORTED BY U.S. Dept. of Energy

1.0071,
A SOLAR ENERGY - PETROLEUM CONSERVATION SYSTEM FOR CURING TOBACCO
J.S. Cundiff, University of Georgia, Georgia Coastal Plain Experiment Station, Dept. of Agricultural Engineering, *Tifton, Georgia* 31794 (7098-20190-010-A)
OBJECTIVE: Determine the system parameters for a tobacco curing system which utilizes solar energy, supplemented by a heat pump to totally eliminate LP gas and fuel oil for tobacco curing.
APPROACH: A scale prototype consisting of three one-fifth scale curing chambers, an existing flat plate solar collector and rock storage and an electric heat pump, to be used in off-peak hours, will be used to cure tobacco in the bulk. Heat from the solar collector will be stored in the rock bed to be used in the curing phase. For the high temperature 170 F, steam drying phase, an electric heat pump will be used to elevate the temperature. Heat will be recovered from the exhaust air during the final phase of curing. A microcomputer will be used to optomize the control functions during the testing of the prototype.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0072,
MOLD PREVENTION WITH ENERGY CONSERVATION DURING HARVESTING AND CURING PEANUTS IN THE SOUTHEAST
J.M. Troeger, University of Georgia, Georgia Coastal Plain Experiment Station, Dept. of Agricultural Engineering, *Tifton, Georgia* 31794 (7702-20190-001)
OBJECTIVE: Develop equipment and procedures for harvesting, curing and storing peanuts to minimize mycotoxin and mold contamination, and maintain maximum quality with a minimum expenditure of fossil fuel energy.
APPROACH: Determine harvesting and curing procedures that will maintain maximum quality of peanuts by minimizing mold and mycotoxin contamination. Determine procedures which will make maximum use of solar, wind and other sources of energy which will decrease dependence on fossil fuel energy and maintain maximum quality. Laboratory controlled experiments will be used to determine limiting conditions. These parameters ill then be applied to production quantities. Equipment and recommended practices will be developed and made available to the peanut producer.
PROGRESS: Tests were conducted to determine the effects of interrupting airflow (and heat), during peanut drying, on energy consumption, drying time and peanut quality. Interrupt patterns included 15, 30, and 45 minutes off per hour and one hour off in four. Airflow rates of 13 and 25 cubic meters/min/cubic meter of peanuts were used. Initial moisture content of the peanuts ranged from 16 to 23% moisture. Final moisture content was 20%. Drying time was not significantly increased by interrupting for 15 minutes per hour or one hour in four, but interrupting for 30 minutes per hour and 45 minutes per hour or one hour in four, but interrupting for 30 minutes per hour and 45 minutes per hour increased drying time by 24% and 62%, respectively. Percentage of sound splits, a measure of quality, was not significantly different among treatments and all were below 4%. The difference in final moisture content between bottom and top of the bin was significantly less for the high air flow rate.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0073,
ENERGY USE IN MARKETING AND PROCESSING FOOD AND FIBER COMMODITIES
J.M. Broder, University of Georgia, U.S. Dept. of Agriculture Commodity Economics Div., Poultry Products Program Area, *Athens, Georgia* 30601 (CE-08-077-13-01-X1)
OBJECTIVE: Develop estimates of energy required in marketing food and fiber commodities, present and future. Conceptualize and develop analytical models for aggregating and disaggregating energy data and studying alternatives relating to energy forms, locational, geographical and seasonal problems, commodity shifts, and long-range programs. Analyze potential energy use with alternative marketing methods, new technology, and conservation practices. Determine effects of modification of regulations on energy use by agricultural marketing firms and of national and international energy policies on costs, prices, location of production and marketing functions, and commodity mix. Suggest policy alternatives which would maintain a viable agriculture.
APPROACH: Develop estimates of energy use in the marketing of selected food and fiber commodities. Conceptualize and test an accounting model for measuring energy use in agricultural marketing and evaluate potential energy requirements with alternative marketing systems. Estimate State energy requirements for marketing by type of energy, season, commodity and function. Study effects of modified transportation and environmental regulations. Develop structural profiles of agricultural marketing firms with inputs and cost measurements.
PROGRESS: Available energy data and studies were reviewed. Schedules and plans for survey of energy use, conservation, and practices in marketing all food and fiber commodities were completed and analysis was begun. A framework for marketing energy data base was developed. A report on energy use and costs in Southern broiler processing plants was published. Data on energy use and costs in rendering poultry products was analyzed and a report was published on solar grain drying systems.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Commodity Economics Div.

1.0074,
UTILIZATION ECONOMICS AT THE REGIONAL RESEARCH LABORATORIES
M.E. Miller, University of Georgia, U.S. Dept. of Agriculture National Economic Analysis Div., *Athens, Georgia* 30601 (NEA-12-107-13-01)
OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for products of the different regions and their comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra and interregional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.
APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.
PROGRESS: Economic advisory and research services were provided administrators and scientists at the regional research laboratories on the feasibility and consequences of various new technological developments. Contributions of economic services were to (a) an AID sponsored study of market potential of composite flour technology in developing countries, (b) a cooperative study between SEA/AR and Oklahoma State University on model tannery operations, (c) a cooperative study involving SEA/AR, FAS and the National Renderers Association on foreign market potential of tallow-based soap detergents, (d) a cooperative SEA-AR and ESCS assessment of new technologies in cotton processing, (e) a cooperative SEA/AR and ESCS assessment of potentials for additional use of crop residues in cattle rations, and (f) an assessment of feasibility and impacts of solar energy uses in agriculture. The latter three studies are continuing under work unit/Project No. NEA-12-107-11-00. Initial results indicated high fractose corn sweetener was not a perfect substitute for other sweeteners used in manufactured products. An update of the analysis contained in a 1975 report on PRO-XAN indicated commercial feasibility was greatly enhanced by new processing technology. An update of 1975 estimates of cost of producing Kenaf verified its continuing potential as a resource for manufacturing paper.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div.

1.0075,
AIR-DRYING AND OSMOVAC-DEHYDRATION OF FOODS WITH SOLAR ENERGY
J.H. Moy, University of Hawaii System, Manoa Campus, Agricultural Experiment Station, Dept. of Food Science & Technology, *Gilmore Hall, Room 102, Honolulu, Hawaii* 96822 (7092-20510-008-A(1))
OBJECTIVE: Using solar air drying and osmovac dehydration determine efficiency of heat and mass transfer, physics and chemistry of effects on tropical food products, sanitation requirements, effectiveness of auxilliary air moving devices, optimum drying design and rate measurements and engineering economics.
APPROACH: Compare direct absorption effects on tropical roots and fruits with effects of solar dryer using forced air, augmented with conventional energy. Determine osmotic dehydration effects when syrup is heated directly by solar radiation. Concentrate osmotic syrup using direct solar radiation and develop system for contacting concentrated syrup with fruits and juices to concentrate solids. Determine drying rates vs. loading density, depth, uniformity, surface/volume, temperatures and moisture contents. Develop criterial to design home or commercial dryers or concentrators.
PROGRESS: Four plexiglass chambers with stainless steel racks were built to explore solarosmotic dehydration of tropical fruits. Chamber temperature reached as high as 50 degrees C after 3-4 hours solar exposure. Weight loss of papaya slices was

about 22% after 8 hours direct solar exposure. Shaded exposure was less efficient, temperature maximum 42 degrees C and weight loss 20%. Efficiency calculations on different type home-made solar dryers indicated they use 1.3 to 4.0% of solar energy available. An air flow, screen-cage solar dryer used 3.4 to 9.0% available solar energy.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0076,

SOIL AND PLANT WATER RELATIONS AND MICROCLIMATE INTERACTIONS AS THEY AFFECT PLANT GROWTH

J.W. Cary, U.S. Dept. of Agriculture, Agricultural Research, Snake River Conservation Research Center, *Rte. 1, Box 186, Twin Falls, Idaho* 83341 (5704-20740-003)
OBJECTIVE: Pinpoint specific short term soil water and microclimate conditions that substantially alter plant production and quality, and to seek practical management techiques to advantage of the new knowledge.
APPROACH: Plant parameters such as water relations, nutrition levels, CO(2) assimilation and yields will be studied on field plots subjected to various methods of tillage and irrigation water management. Growth chambers will be used in the winter to provide preliminary information for optimum experimental design and procedures. Root systems will be studied in both the field and laboratory with repect to soil structure, temperature nutrition, and water relations. Emphasis will be on intensive short term measurements of plant physiological reponse in the field to soil and microclimate conditions that can be quantitatively defined and monitored.
PROGRESS: A study of coupled heat and water vapor flow in soil resulted in the derivation of a fundamental equation that enables predicting temperature induced water vapor flow from the soil's bulk density, water and quartz contents, temperature distribution, and its saturated thermal conductivity. This equation will be useful in the analytical solution of soil drying and water storage problems as well as engineering designs associated with the safe burial of radioactive wastes and the storage of solar energy in soil for later retrieval during cold periods. The development of appropriate theory and experimental techniques were begun on three studies involving: Creation of design criteria to see if it is feasible to develop a microprocessor to schedule irrigations from soil water measurements. The charaterization of leaf properties that limit CO(2) fixation of plants under field conditions. The treatment and propagation of pinto bean seeds to be screened for shifts toward cold resistance following chemically induced mutations.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Idaho - Montana - Utah Area

1.0077,

UTILIZATION ECONOMICS AT THE REGIONAL RESEARCH LABORATORIES

M.E. Miller, U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div., *1815 N. University St., Peoria, Illinois* 61604 (NEA-12-107-17-05)
OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for products of the different regions and their comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra and inter-regional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.
APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.
PROGRESS: Economic advisory and research services were provided administrators and scientists at the regional research laboratories on the feasibility and consequences of various new technological developments. Contributions of economic services were to (a) an AID sponsored study of market potential of composite flour technology in developing countries, (b) a cooperative study between SEA/AR and Oklahoma State University on model tannery operations, (c) a cooperative study involving SEA/AR, FAS and the National Renderers Association on foreign market potential of tallow-based soap detergents, (d) a cooperative SEA/AR and ESCS assessment of potentials for additional use of crop residues in cattle rations, and (f) an assessment of feasibility and impacts of solar energy uses in agriculture. The latter three studies are continuing under work unit/Project No. NEA-12-107-11-00. Initial results indicated high fractose corn sweetener was not a perfect substitute for other sweeteners used in manufactured products. An update of the analysis contained in a 1975 report on PRO-XAN indicated commercial feasibility was greatly enhanced by new processing technology. An update of 1975 estimates of cost of producing Kenaf verified its continuing potential as a resource for manufacturing paper.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div.

1.0078,

NEW AND IMPROVED SYSTEMS, METHODS, AND TECHNIQUES FOR PROCESSING HARDWOODS

H.N. Rosen, U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station, *Carbondale, Illinois* 62901 (NC-3201)
OBJECTIVE: Develop new and improved processes and conversion systems, reduce processing costs in the hardwood products industries, and extend the supply of high-value and high-quality hardwood timber.
APPROACH: We will develop new drying methods (high presure) as well as improved old ones (solar drying) to rapidly dry lumber with minimal defect. Fundamental work in basic heat and mass transfer will support this work. New techniques will be applied to the machining of dimension material so that the best surface with the least waste can be obtained. The new technology developed in drying and machining will be applied to a model hardwood dimension plant. Characterization of raw material, adaptability of new technology, and an evaluation of process economy for finished parts will be determined.
PROGRESS: If we are to extend the supply of high-value species through the increased use of logging residues, we must improve our secondary processing systems. New methods must be developed in drying and machining to reduce cost, time, and energy consumption. A solar kiln, using recycled beverage cans in the collector units, has been built for predrying hardwood lumber. During the summer, the solar kiln was able to dry 4/4 yellow-poplar from green (85% moisture content) to 15% moisture content in just 8 days. The quality of lumber dried in the solar kiln was better than that of air dried lumber, and the drying occurred more rapidly. Tests with a prototype jet dryer showed that 4/4 cottonwood and hard maple lumber could be effectively predried at temperatures to 300 F before completing the drying in a conventional kiln. Energy recovery from the vent air streams of dry kilns was demonstrated. A mathematical characterization of jet drying was shown to fit our drying data very well. Knife planing across the grain with rake angles up to 60 reduced the depth of defect from an excess of 1/16 inch to less than 1/32 inch as compared with conventional knife planing along the grain. A high-quality flake for particleboard instead of a planer shaving was produced as a secondary product.
SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, North Central Forest Experiment Station

1.0079,

HANDBOOK AND GUIDE FOR THERMAL ENERGY STORAGE APPLICATIONS IN SOLAR HEATING AND COOLING SYSTEMS

R.G. Matlock, U.S. Dept. of Energy, Argonne National Lab., *9700 S. Cass Ave., Argonne, Illinois* 60439 (ERDA EA-01-01)
The purpose of the proposed program is to assemble, evaluate, restructure, and standardize data and information on TES technology in form designed to satisfy a broad range of user needs. The proposed handbook and guide is intended as an easy-to-use, up-to-date source of information and data on TES technology and cooling systems.
SUPPORTED BY U.S. Dept. of Energy

1.0080,

IMPROVED ANALYSIS AND DESIGN OF FARM BUILDINGS

J.O. Curtis, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Urbana, Illinois* 61801 (ILLU-10-0372)
OBJECTIVE: Conceive and evaluate improved procedures of structural analysis and design. Develop and evaluate new or improved structural systems. Evaluate new building materials or new uses of existing materials for application in farm building construction.
APPROACH: A proposed improved analysis or design procedure will be applied in the design of a group of appropriate structural elements. Load tests will then be performed on these elements in full size or model form and the results of the load tests will be compared with those predicted by the analysis or design procedure. New materials and structural schemes will be evaluated by using them in production buildings and observing their performance and by subjecting them to a variety of simulated and accelerated tests.
PROGRESS: A study was recently completed to evaluate the relative strength against lateral loads of six improved building post anchorage systems. The strength of each system was compared to that of a control system consisting of a bag of dry concrete mixture placed around the base of the post and then only soil backfill around the post above the concrete base. While all systems tested were stronger than the control, only one system was strong enough to develop the full bending strength of a dressed 6 x 6 post. During the Summer of 1978, solar collectors were added to the south facing halves of the roofs of two existing swine buildings on the University Farms. One collector is a bare-plate type consisting of dark green steel roofing and the other is a covered-plate type consisting of corrugated glass fiber reinforced plastic over an absorber plate formed by painting the existing asphalt shingle roof black. The performance of the two collectors is being monitored to determine their effectiveness in adding heat to the incoming ventilation air of these buildings. Farm building cost data are being used to project future costs using time series analysis. Preliminary results indicate a high degree of accuracy for short time predictions. Work continues on cost/energy effective buildings. Various configurations are being studied to assess their potential.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Illinois

1.0081,

SOLAR DRYING OF HIGH SPEED HAY ACCUMULATOR PACKAGES

G.C. Shove, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Urbana, Illinois* 61801 (7002-20190-014A(1))
OBJECTIVE: Determine the design parameters for solar hay driers, evaluate the cost benefit ratio of these driers, and investigate the relationship of hay density to the drying process.
APPROACH: An air plenum capable of drying hay packages of various sizes and density will be used to gather drying process data. This will be used in an attempt to determine optimum bale density and air entry patterns. This will be used in conjunction with a poratable covered plate solar energy collector to study collector parameters as they relate to the drying of large hay packages. The cost-benefit evaluation will be made on a solar hay drying facility which has the capacity to dry 36 large round bales, utilizing a 10,000 square foot covered plate collector which is incorporated into the roof and the south wall of the building.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0082,

OPTIMIZATION OF FLAT PLATE SOLAR COLLECTORS FOR GRAIN DRYING

G.C. Shove, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Urbana, Illinois* 61801 (3090-20594-033-G)
OBJECTIVE: Optimize the design of solar collectors for grain drying systems, particularly solar collectors incorporated in farm buildings.
APPROACH: Correlate the variations of the collected energy and design parameters of solar collectors incorporated into farm buildings. Determine optimal design of solar collectors for specified agricultural

applications. Develop guidelines for selection and management solar collectors applied to grain drying.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Illinois - Indiana - Ohio Area

1.0083,

THE EFFECTS OF RISK ON ILLINOIS FARMERS RELATED TO FARM ORGANIZATION, TAX REGULATION AND FARM SIZE

S.T. Sonka, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Economics, *Urbana, Illinois* 61801 (ILLU-05-0305)

OBJECTIVE: Estimate crop variability by region in Illinois and its impact on modern farming operations. Estimate the effect of structural and financial organization and farm size on the ability to survive adverse occurrences. Estimate effects of risk, tax regulation, and farm organization on farm size. Adapt or develop models useful in assessment of risk with variations in tax regulation, farm organization and farm size.

APPROACH: An attempt will be made to assess the risk and survival attributes of various farm production and financial decision strategies. Also the effect of regulations on farmer decision will be considered. Statistical analysis of farm production variability will provide a basis for understanding the risk position of Illinois Farmers. Simulation and optimization techniques can then be employed to compare various decision strategies farmers can employ.

PROGRESS: During this reporting period evaluation continued on the economic attractiveness of hail suppression. This technology was found to be relatively more attractive in the Plains states than in the midwestern or eastern crop producing areas. Precipitation augmentation was generally found to have more of an economic impact than would hail suppression. The historic variability of corn yields in Illinois has been evaluated. Generally counties in southern Illinois were found to have experienced greater yield variability than those in central or northern Illinois. Solar grain drying was found to be uneconomic relative to high temperature systems at current prices. Increasing fuel costs only slightly narrowed this cost differential due to the higher fixed costs of the solar system. Relative to other low temperature systems, the solar dryer was nearly competitive even at current prices. Net returns to land based on returns of grain farms on highly productive land in Illinois are compared recent land values. Several other variables are compared in order to explain the price of land, including the mortage rate of interest, the rate of inflation, corn price, corn yield, and the real rate of interest. It is clear that much of the current price of land must be explained on the assumption of continuing increases in technology being captured by landowners and a continuing high rate of inflation.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Illinois

1.0084,

PHOTOELECTRIC AND PHOTOCHEMICAL STUDIES OF BACTERIORHODOPSIN

H. Frauenfelder, University of Illinois, Urbana Champaign Campus, Graduate School, Dept. of Physics, *Urbana, Illinois* 61801 (INT78-27606)

The objective of this U.S.-Hungarian collaboration is to study the mechanism of light-energy conversion by bacteriorhodopsin (BR). The goal of the research is to obtain a complete set of parameters for the BR photochemical cycle. BR is the purple colored protein found in the membrane of certain bacteria which live in concentrated salt ponds. BR transfers sunlight energy into electrochemical energy and thereby provides an alternative energy source to respiration. This electrochemical energy enables the bacteria to sustain their metabolic functions.

The Hungarian group at the Biological Research Center of the Hungarian Academy of Sciences will investigate the photoelectric properties of BR in model membrane systems. Photoelectric spectroscopy will be used to measure light/energy transduction and to study the proton pumping function in BR. The American group at the University of California at San Francisco will produce and characterize the purple membrane samples of BR. The photochemistry of BR in purple membrane suspensions will be studied over wide ranges of time, temperature, pressures, pH values, and salt concentrations at both Urbana and San Francisco. The two American groups will then formulate a general kinetic model to describe, in quantum mechanical terms, the photochemical cycle and photoelectric function of bacteriorhodopsin.

SUPPORTED BY U.S. National Science Foundation, Directorate for Scientific Technological & Internat. Affairs, Div. of International Programs

1.0085,

DRYING AND CONDITIONING OF FARM GRAINS

G.C. Shove, University of Illinois, Urbana Champaign Campus, School of Engineering, Dept. of Agricultural Engineering, *106 Engineering Hall, Urbana, Illinois* 61801

A computer model which simulates the performance of flat plate, single cover, air heating solar energy collectors has been developed and will be used to optimize the design of solar collectors applied to grain drying systems. Different values of collector design parameters were put into the model to determine which parameters significantly affect collector performance. Construction plans for agricultural solar systems will be modified and improved as optimization output is obtainined from the model.

Data collected on low temperature corn drying bins during the 1978 drying season indicated an energy consumption of less than 0.2 kWh/bu per percentage point of moisture removed when no heat was applied. Energy consumption increased to 0.3 kWh/bu per percentage point of moisture removed for systems employing electric heat. The data indicate that corn can be dried with less energy if the energy input is applied to the delivery of air rather than used as heat to increase the drying air temperature. On the other hand, if required heat can be collected from the sun, energy costs can be minimized while maintaining the higher moisture removal potential characteristic of supplemental heat grain drying system.

SUPPORTED BY U.S. Dept. of Energy

1.0086,

SOLAR HEATING-COOLING DEMONSTRATION POND PROJECT

J.J. Birdcell, Indiana Vocational Technical College, Gary Campus, Undergraduate School, *1440 E. 35th Ave., Gary, Indiana* 46409 (EG-77-C-02-4405)

SUPPORTED BY U.S. Dept. of Energy

1.0087,

HEATING AND COOLING A SWINE FARROWING HOUSE WITH SOLAR ENERGY

A.C. Dale, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (7002-20400-014A(1))

OBJECTIVE: Determine the effectiveness of the Kansas State solar energy collector and storer in heating and cooling a swine farrowing shelter under Indiana conditions and observe effects of heating on control of infectious pathogens.

APPROACH: Adapt the Spillman design and construct the collector-storage unit as attachment to existing Purdue farrowing shelter. Obtain data on temperature, energy, and air flow to determine system performance. Monitor swine health and determine rate of gain of litters. Supply performance data to refine Spillman's model.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Atlantic Area

1.0088,

SOLAR ENERGY COLLECTION, STORAGE, AND UTILIZATION FOR THE IMPROVEMENT OF LIVESTOCK AND CROP PRODUCTION

A.C. Dale, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND046015)

OBJECTIVE: Develop solar energy collection systems, solar energy storages, and procedures for the utilization of solar energy to modify the environment for the improvement of both animal and crop production in cold and hot weather.

APPROACH: An insulated solar energy collector will be fabricated with reflectors to concentrate the solar energy. The reflectors will be placed at the top and bottom of the collector at such an angle so as to reflect additional solar energy into the collector to improve efficiency. Air will serve as the energy exchange medium between the collector and storage field. The solar heated air will be blown through pipe in an insulated energy storage field of soil and groundwater at a depth of eight feet for transfer of the heat to these materials. Starting in late August or early September, the collector will be placed in operation to build up the stored energy for use in heating animal shelters, shelters, greenhouses and farm houses in the winter. The stored heat will be recovered in a similar manner to which it was added to the soil and groundwater storage with the energy first being used to heat a greenhouse.

PROGRESS: A solar energy collector, storage and utilization unit 8' high by 32' long has been built onto the south side of a twelve-sow farrowing unit of an existing farrowing house. The cross section of the unit consists of two cover plates of fiberglass about 1 1/2' apart placed about 1 1/2' from a concrete block storage. The energy storage is a 16' thick vertical wall of solid concrete blocks with 3/16' vertical openings between to form a porous wall. Ventilation air enters at the top and bottom of the two layers of fiberglass moving through a slot in the middle of the second layer of fiberglass into the plenum in front of the concrete block wall. From this plenum it is drawn by fans into the farrowing house. Results to date show that the system is working well. Air coming through the solar collector and storage is entering the building 20 degrees to 30 degrees F above the outside air. Thus supplementary heat requirements have been reduced. Also, since the temperature of the entering air has been raised, the adverse effect on the pigs is less severe. A solar energy collector and soil and groundwater energy storage system has been set up to collect and store solar energy for heating greenhouses. Results to date have been mixed. (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Indiana

1.0089,

SOLAR CONCENTRATION OF LIQUID FOODS

M.R. Okos, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (7005-20510-021-A)

OBJECTIVE: Determine feasibility of using solar energy for liquid food concentration using membrane processing, and other low energy unit operations such as immobilized enzymes and membrane demineralization systems.

APPROACH: Conduct experiments to determine effects of variable temperature on flux, rejection, fouling, microbial growth and membrane life using reverse osmosis and/or high pressure filtration for concentration of fruit juices, tomato juice and milk. Measure effects of residence time, microbial growth, sanitation on different liquid foods using solar energy as primary source, in a solar collector specifically designed for handling liquid food materials. Compare results with other potential low energy food processing unit operations, e.i., immobilized enzyme reactors and determine potential and compatibility of operation with solar availability.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0090,

PROCESSING OF AGRICULTURAL PRODUCTS

M.R. Okos, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND046036)

OBJECTIVE: Develop energy efficient processing operations. Develop processing operations that minimize waste output. Develop economical processes for utilization and upgrading agricultural by-products and residues.

APPROACH: In order to accomplish the above objectives it will be first necessary to monitor the energy use and wastes output of various food and grain processing operations. This information is important in identifying the significant variables causing high energy use and waste output. Modification in present processing techniques can save energy and lower the waste load. Alternative processing techniques such as concentration of dairy and vegetable products using membrane processing can lower energy costs. Careful investigation into the fundamental mass transfer, heat transfer and kinetic properties of foods will be investigated in order to design more efficient processes. Food processing by-products such as whey and underutilized foods such as corn and alfalfa will be enzymatically, chemically and mechanically treated to provide useful products for human consumption. Fermentation techniques will also be investigated to upgrade processing residues. Once the fundamental information is obtained, computer models can be developed to aid in the selection of energy efficient, economical and waste free processes.

PROGRESS: Salt Removal from acid milk whey. A 40% removal of calcium and phosphorous at 140

degrees C for 10 minutes. The precipitation had a composition of 40% fructose and 60% ash. Lower temperatures also caused precipitation but longer times were necessary. Solar Energy Storage. Comparative tests were performed on soil, rock, and PCM (phase change materials) as to their ability to store energy. Air at 25 degrees C and 50 degrees C was pumped through beds of the storage material and the thermal response noted. The time needed to add or recover energy was shortest for rock and largest for soil. Modeling studies were performed. The cost to store a given amount of energy was found to be greatest for PCM and lowest for soil. Drying of Corn. Studies were performed on several varieties of yellow dent corn. The temperature range investigated was from 10 degrees C to 150 degrees C. Thermal conductivity, density, breakage and moisture were determined during drying. Models were developed to give detailed drying equations. (Text Truncated - Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Indiana

1.0091,
ENERGY EFFECTS IN CROP-ENVIRONMENT INTERACTIONS
R.M. Peart, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND046021)
OBJECTIVE: Determine the effects of energy inputs such as solar radiation, fertilizers, tillage cultivation, harvest, pesticides and artificial drying methods on the quantity and quality of major Indiana crops including corn, soybeans, alfalfa and wheat.
APPROACH: Develop mathematical models of specific processes for simulation studies using environmental data and energy source data as inputs. These simulations can be re-run quickly and economically using historical weather data and varying energy inputs. These results may then be evaluated on the basis of effects on food production, economic returns, energy consumption or energy input/output ratios. A major application will be grain drying with various combinations of solar energy, gas fuel, and electricity. Crop ecosystem simulation work will also be continued to better advise farmers on alfalfa management. Alfalfa drying using solar energy needs research. Weather data is available, an excellent alfalfa growth simulator, SIMED, has just been developed and solar drying of corn is being studied, so the alfalfa drying work could follow naturally. Studies of energy effects on total agricultural production will also be started.
PROGRESS: Work included alfalfa hay dry-down and harvesting losses, solar drying of wheat and corn cob gasification for grain drying. The wheat drying work was in cooperation with SEA Agricultural Engineering, John R. Barrett, Jr. Drying and rewetting data were obtained for use in a wheat drying simulation. Wheat was harvested at 30% down to 14% wet basis and dried at 26.7, 50.0, 67.5 and 87.8 degrees C and rewetted in small batches. Drying and rewetting curves were developed. Wheat was found to rewet at virtually the same rates, i.e., with the same heat and mass transfer characteristics as for drying. Solar drying of wheat was found to be feasible for double-cropping of wheat followed by beans, if batch-in-bin drying equipment and solar collectors are on hand. Data was obtained and a model was developed for drying and dry matter losses from alfalfa hay harvested under Midwest conditions. The model includes loss equations for the respiration process and the mowing, raking, and baling operations. A dry-down model within the program uses weather information to simulate actual field curing. (Text Truncated - Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Indiana

1.0092,
ECONOMIC ANALYSIS OF RESOURCE POLICY ISSUES IN AGRICULTURE
W.E. Tyner, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Economics, *Executive Bldg., West Lafayette, Indiana* 47907 (IND045076)
OBJECTIVE: Estimate the efficiency of alternative leasing policies in achieving government objectives for resource disposition, estimate the efficiency and equity impacts of tax and regulatory policies for energy sources with emphasis on the agricultural sector, determine price and usage conditions for solar energy with capital sharing for farm and rural residential applications, and estimate the impacts of resource policies in developing countries with emphasis on the indirect impact of such policies on American agriculture.
APPROACH: The principles of welfare theory and public finance and various quantitative methods will be used to estimate impacts of alternative resource policies in agriculture. Monte Carlo simulation and game theory will be used to handle uncertainty, and capital budgeting and investment analysis will be used to compare energy consumption alternatives. Cost-benefit analysis will be used for evaluation of resource investments.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Indiana

1.0093,
DRYING, HANDLING & STORAGE OF GRAIN CROPS
G.H. Foster, Purdue University, School of Agriculture, Dept. of Agricultural Engineering, *Life Sciences Bldg., West Lafayette, Indiana* 47907 (IND0046039)
OBJECTIVE: Improve post-harvest conditioning, handling and storage of grain crops through reduced damage, lowered cost, reduced energy requirements and development of alternate energy sources.
APPROACH: Various combinations of high temperature drying and in-storage low temperature drying the latter utilizing both natural and solar heated air, will be evaluated in terms of grain quality maintenance and energy use efficiency. Optimum moisture levels for each phase of the process will be determined, considering weather and crop conditions. Methods and equipment for reducing velocity and impact damage of grain from gravity spouts will be designed, tested and evaluated. As an energy conservation measure, heat pump will be tested for low temperature grain drying and for higher temperature operation with recirculation of the drying air. Solar energy and utilization of biomass- mainly crop residues - will be studied as alternate energy sources for grain drying.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Indiana

1.0094,
STRUCTURAL AND PHOTOCHEMICAL PROPERTIES OF HYDRATED CHLOROPHYLL A AGGREGATES
F.K. Fong, Purdue University, School of Science, Dept. of Chemistry, *Executive Bldg., West Lafayette, Indiana* 47907 (PCM77-26736)
Preliminary evidence has been obtained that chlorophyll a dimers are capable of photochemically splitting water in vitro, simultaneously evolving hydrogen and oxygen. The ratios of hydrogen: deuterium and oxygen isotope peaks correspond to predictions, and the wavelength dependence of the reaction indicates that chlorophyll is functional. The goal of this project is to scale up the yield of hydrogen and oxygen and to find conditions for sustaining the reaction. If successful, this study would have important implications for energy technology and for understanding photosynthesis in vivo.
SUPPORTED BY U.S. National Science Foundation, Directorate for Biological Behavioral & Social Sciences, Div. of Physiology Cellular & Molecular Biology

1.0095,
EXPERIMENTAL AND THEORETICAL STUDY OF THE THERMAL PERFORMANCE OF A HYBRID SOLAR RESIDENCE FOR THE FARM OF TODAY AND TOMORROW
R.D. Crites, Ames Design Collaborative, *Urbandale, Iowa* 50322 (EG-77-G-04-4136)
This project will study the thermal performance of a solar-heated residence in order to develop a design formula that will incorporate passive concepts in optimal ways and provide a building design prototype. The residence to be studied uses several passive solar energy concepts, including a solar pond. These concepts have been used in previous designs, but have never been combined to the degree they will be in this research. It is estimated that except for the electrical energy needed to operate fans and water pumps, this composite passive system will provide 100% of the heating needs for the house. During the cooling season, however, the house will operate only partially in the passive mode, using a heat exchange unit. The thermal performance of the building will be monitored by pyranometers and thermocouples. Also, this project will develop a computer model of the passive solar house coincident with actual house construction. This new model and the hybrid model's prediction accuracy will be perfected using the measurement data obtained from the solar house. (DOE/CS-0010)
SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Div. of Solar Energy, Office of Solar Application for Buildings

1.0096,
SOLAR ENERGY FOR GRAIN DRYING
C.J. Bern, Iowa State University of Science & Technology, Iowa Agricultural & Home Economics Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (3090-15701-018-A)
OBJECTIVE: Test methods of applying solar energy to low temperature drying of corn.
APPROACH: The following grain drying systems will be tested and their performance compared: A solar heat supplemented system using electric heat at night. A system using solar heat supplementation through a heat pump. A low-temperature electric drying system used as control. A prototype digital logic control system will be designed to reduce the management complexity of operating a combination solar-electric drying system.
PROGRESS: Three drying systems were again compared: One with 2.4 Kw of resistance heat plus solar supplementation from a collector constructed for '74-'75, a second with 2.4 Kw of resistance heat only, and a third with a 24,000 Btu/hr heat pump supplemented with a solar collector constructed this season. Improved instrumentation was developed and work on an automatic control system for solar-electric drying is in progress.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Kansas - Nebraska Area

1.0097,
A STRUCTURALLY INTEGRATED SOLAR COLLECTOR WALL FOR LIVESTOCK BUILDINGS
D.S. Bundy, Iowa State University of Science & Technology, Iowa Agricultural & Home Economics Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (IOW02330)
OBJECTIVE: Construct experimental integral wall collector. Gather data on operation. Evaluate design and performance of collector wall, both functionally and economically. Prepare evaluation, with recommendations for practical farm use, for technical publication and M.S. Thesis.
APPROACH: An integral wall solar collector will be constructed on isu Ag 450 Farm. Data on collector and ventilation system performance will be collected over two winters and one summer. Preliminary results will be reported in a technical paper after the first winter, and final evaluation with design recommendations will be reported in an M.S. Thesis after the second winter of operation.
PROGRESS: An integral wall solar collector was built during the past fall on the ISU Ag. 450 Farm. The collector is made of an outer skin of corrugated fiberglass on vertical firring strips attached to a black-painted, concrete-block wall. Air is drawn down between the corrugated fiberglass and the concrete-block wall and then pulled up through the center cores of the blocks, entering the building at the ceiling level. The concret blocks are used for thermal energy storage and temperature moderation. The wall is insulated with fiberglass on the inside of the block wall to prevent condensation. Data is currently being collected.
SUPPORTED BY Iowa State Government

1.0098,
ENERGY CONSERVATION IN DRYING, CONDITIONING AND STORING CORN ON FARMS
G.L. Kline, Iowa State University of Science & Technology, Iowa Agricultural & Home Economics Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (IOW02132)
OBJECTIVE: Evaluate improved methods and equipment for drying, conditioning and storing corn on farms to conserve energy, maintain grain quality, and provide suitable capacities in relation to harvest operations.
APPROACH: Investigate the use of solar energy as supplemental heat or as the sole source of added heat for drying shelled corn in bins on farms. Design and develop solar energy collection and storage devices applicable to grain drying systems. Investigate low temperature drying and combinations of heated air and low temperature drying as methods of reducing the energy required for drying corn. Investigate methods of extending the allowable time for low temperature and unheated air drying, including chemical

treatment and intermittent removal of small amounts of moisture. Conduct pilot and full-scale tests of promising drying and conditioning methods and determine capacity in relation to production and harvest operations.

PROGRESS: Three experiments of corn drying using solar energy are in progress. A digital automatic fan and heater control system is being field tested using a 5.5-m low-temperature drying bin equipped with an 18-m 2 fixed suspended-plated solar collector. The control system seeks to minimize electrical energy use by turning off the heater or the fan and heater during periods of poor drying weather. The automatic control system bin used 24% less electrical energy than a low-temperature control bin operating under similar conditions in the first year of testing. A combination desiccant/low-temperature system is being tested using a second 5.5-m bin. Corn overdried to under 10% moisture is mixed with wet corn at harvest to give 20% moisture, which is dried using solar heat and a low airflow rate. Electrical energy use for the desiccant system was less than half of that for a low-temperature control bin operating under similar conditions in the first year of testing. A corn drying system has been fitted to an existing 232-m 2 air collector designed for heating a school gymnasium near West Branch, Iowa. During the Fall of 1978, 127 tonne of corn was stir dried from 20.4% to 14.8% moisture using solar-heated air.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Iowa

1.0099,
MONITORING AND MODELING THE DISPERSIVE CAPABILITIES OF THE RURAL ATMOSPHERIC PLANETARY BOUNDARY LAYER

E.S. Takle, Iowa State University of Science & Technology, Iowa Agricultural & Home Economics Experiment Station, Dept. of Agronomy, *Beardshear Hall, Ames, Iowa* 50010 (IOW02116)

OBJECTIVE: Develop mathematical and computer models specifically tailored to rural atmospheric dispersion problems such as transport of odor, pesticides, dust, spores, pollens and other allergens. Carry out remote and in situ measurements of the rural atmospheric boundary layer to obtain a better quantitative understanding of rural dispersion characteristics. Develop a predictive model for growth and decay of nocturnal inversions, and test and modify this using detailed surface, balloon-borne, and remote measurements. Incorporate the results of 2 into the models of objective 1.

APPROACH: Time-dependent dispersion models incorporating gravitational settling and dry deposition will be applied to particle drift problems. Time-independent area source models will be modified to address rural vapor drift situations. Surface observations of temperature, humidity, radiation, wind speed and wind direction will be made. Vertical profiles of meteorological variables and detailed structure of thermal inversions will be obtained from balloon-borne sensors and acoustic echo-sounder. These observations will be used to determine both the climatology and the dynamics of the dispersive properties of the rural atmosphere. Particular attention will be given to the anomalous transport conditions produced by nocturnal inversions. Wind shear, thermal structure, and mixing properties observed during these events together with surface measurements will be used to test predictive models of nocturnal inversion growth and decay.

PROGRESS: Atmospheric model of particulate (dust) transport from line source (roadway) has been written up for publication. Study of wind and solar energy available in the planetary boundary layer has been completed. Results suggest wind and solar energy are complementary on an annual basis for central Iowa (and probably most mid-latitude stations having a continental climate and no significant orographically induced wind patterns); that is, in summer there is a solar energy maximum coinciding with a wind energy minimum. The peak of wind energy (April) does not quite coincide with the solar energy minimum (January) although wind energy is high in January. Complete study results have been accepted for publication. A new procedure for boundary-layer, namely the finite-element method, is being studied for potential application to air flow problems near the earth's surface. (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Iowa

1.0100,
IMPROVED SYSTEMS FOR GRAIN HARVESTING, DRYING, CONDITIONING AND STORAGE ON FARMS

G.L. Kline, Iowa State University of Science & Technology, U.S. Dept. of Agriculture Agricultural Engineering Res. Div., *Beardshear Hall, Ames, Iowa* 50010 (3408-20590-001)

OBJECTIVE: Investigate improved systems for harvesting, drying, conditioning, and storing corn on farms to reduce energy use and cost, maintain quality, and provide suitable system capacities.

APPROACH: Use systems analysis to develop models for complete systems of corn harvesting, drying, conditioning, and storage. Develop computer simulation programs to compare representative farm drying systems such as continuous flow, batch-in-bin and continuous flow in bin. Analyze systems that use renewable sources of energy such as solar grain drying, low temperature drying, and appropriate combinations. Investigate systems for using crop residues for drying shelled corn with heated air. Develop systems for harvesting, transporting, storing and producing energy from corn crop residues. Investigate methods of energy conversion including direct burning, pyrolytic decomposition, and methane generation. Construct pilot-scale equipment and measure useable energy content of crop residues. Develop integrated systems for harvesting, drying, and storing corn that emphasize reduced energy requirements and efficient operation on different size farms.

PROGRESS: Complete systems for harvesting, drying, conditioning, and storing corn on farms were investigated using computer simulation. CORNSIM was developed as a model of corn production from planting through harvest. The corn production model was developed to provide simulated corn harvest data which is the input to the follow-on low-temperature drying and storage model. CORNSIM and the companion drying model provide a means of studying the relationships among weather, crop acreage, machine capacity, management strategy, drying energy, and resulting grain quality. The systems analysis uses weather data for Central Iowa for 1958 through 1975. CORNSIM accounts for the interactions between weather, machine capacities, crop development, and management strategy. The simulation provides the grain moisture content from dough stage to harvest with respect to time. Subject to the limitations of machine capacity, management decisions, field trafficability, and weather, the harvesting operation is simulated. The harvested grain flow data provides grain quantity, moisture and temperature on a daily basis. Validation of the corn production model uses historical data of the Iowa Crop and Livestock Reporting Service.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Great Plains Area

1.0101,
SOLAR ENERGY FOR CORN DRYING ON FARMS

G.L. Kline, Iowa State University of Science & Technology, U.S. Dept. of Agriculture Agricultural Engineering Res. Div., *Beardshear Hall, Ames, Iowa* 50010 (3408-20590-002)

OBJECTIVE: Design and develop techniques and equipment for collecting, storing and utilizing solar energy for drying shelled corn on farms.

APPROACH: Develop solar energy collection devices based on present knowledge and incorporate new findings on methods and materials. Design and develop solar energy storage techniques and equipment to utilize solar heat in grain drying systems. Adapt computer simulation models to predict energy collected and drying potential based on grain deterioration rates and weather records.

PROGRESS: Nine pilot-scale solar collectors were retained from previous test work. Two new pilot-scale collectors were designed for multiple-use applications on farms. The new collectors were rectangular in shape, rigid frame construction, and built from low-cost durable materials. The multiple-use collectors operating in the suspended-plate configuration provide a low-temperature rise suitable for grain drying. The collectors operating in the single channel configuration provide a moderate temperature rise suitable for water heating and space heating either in the farm home or other farm buildings. Tests have been conducted at relatively high air flow rates for the grain drying regime and at low air flow rates for other farm applications. Solar radiation and temperature data are being analyzed to compare the efficiency of solar energy collection of the different collectors. A technical article was completed and a presentation made of the economic analysis of six different types of solar collectors suitable for low-temperature grain drying. Presentations were made and published about the computer simulation model for low-temperature rise air collectors suitable for grain drying.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Great Plains Area

1.0102,
VACUUM DISTILLATION OF FUEL ALCOHOL USING SOLAR ENERGY

M.L. Holden, University of Iowa, School of Engineering, Dept. of Energy Engineering, *Jessup Hall, Iowa City, Iowa* 52240

OBJECTIVE: To determine the economic and energy feasibility of on-farm to farm coop size fuel alcohol production plants that utilize vacuum distillation and solar energy.

APPROACH: Design, build, and test a solar assisted vacuum distillation unit, and analyze the experimental results in the categories of; energy balance, useful energy gain from solar collectors, time and effort requirements of the production system, rate and proof of production, and the collector area to production rate ratio.

PROJECT BACKGROUND: Experiments with a batch vacuum distillation unit which used solar energy proved the energy efficiency of combining vacuum distillation and solar energy. Utilization of vacuum distillation allows for operation of the collectors at low temperatures yielding high collector efficiencies and the use of low cost flat plate solar collectors. The need for a constant high proof product necessitated the switch to a continuous distillation process.

PROJECT DESCRIPTION: A thirty foot long, four inch diameter continuous distillation column, and a 200 square foot collector array are being constructed with operation anticipated by January 1981. Initially, a constant temperature heat source will be used to investigate the vacuum distillation process, and then water heated with solar energy will serve as the heat source. Thus, the engineering parameters of vacuum distillation and solar energy will be determined independently.

SUPPORTED BY Iowa State Government

1.0103,
ASSESSING SOLAR ASSISTED FUEL ALCOHOL PRODUCTION IN THE STATE OF IOWA

T.F. Smith, University of Iowa, School of Engineering, Dept. of Energy Engineering, *Jessup Hall, Iowa City, Iowa* 52240

OBJECTIVE: To improve the State of Iowa energy self-sufficiency through the use of solar energy to produce fuel alcohol.

APPROACH: To determine the role of solar energy in fuel alcohol production from on-farm to commercial scale production sizes, four categories of research will be pursued: 1) field survey of on-farm to large commercial scale operators, 2) library research of pertinent literature, 3) experimentation at The University of Iowa, and 4) engineering analysis of existing and conceptual alcohol production facilities which utilize solar energy.

PROGRESS: Several fuel alcohol producers have been interviewed for their experiences and advice. Previously published literature on solar assisted fuel alcohol production is being reviewed. Solar insolation, corn production and prices, and rainfall have been examined over a several year period for input to solar assisted fuel alcohol feasibility. A 200 square foot collector array and a four inch continuous vacuum distillation column will be interfaced and on-line for generating experimental data. Criteria for analyzing fuel alcohol production facilities have been established and input data are being sought.

SUPPORTED BY Iowa State Government

1.0104,
DESIGN PARAMETERS FOR OPTIMUM ENVIRONMENTS IN CONFINEMENT SYSTEMS FOR LIVESTOCK-ENERGY-USE EFFICIENCY

C.K. Spillman, Kansas State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00837)

OBJECTIVE: Develop, validate and use a dynamic simulation model, of the internal temperatute and humidity environment in an animal shelter; predict the influence of outside weather, effect of different building features, and location of heat exchanger surfaces, and scheduling of animals into structures. Possible reduction in electrial energy or fuel will be estimated.

APPROACH: Simulation model used to predict the performance of a solar swine farrowing house will be

expanded. Verification will involve using swine buildings instrumented for measuring inside temperature and humidity, outside climatic conditions, and operation of fans and furnaces. Actural weather data will be used to predict the effect of various building features and scheduling animals. Performance of ventilating systems will be experimentally evaluated and modelled.
PROGRESS: Research during the reporting period was directed toward a change in the emphasis of this project towards energy conservation in animal shelters. A revision of the project was written for review within the department and submission to the Experiment Station for approval. The thrust of work has been: 1) to continue development of computer model for predicting farrowing house environment and 2) to develop instrumentation for measuring environmental and equipment parameters to verify the computer prediction. Instrumentation has been developed to measure fan revolutions and furnace operation in addition to temperatures in an animal shelter. Relative humidity is measured by a hygrothermograph. The equipment has been installed in a solar heated farrowing house on each of two farms in North Central Kansas. This work is in conjunction with a project to determine the effectiveness of solar collectors used for preheating ventilating air where other parameters are needed for verification of solar collector performance. Although the computer simulation is a simplified, first generation development, we have been able to show one producer that he could make significant reductions in energy use by changes to the ventilating system and its management. He will be making changes before the 1979-80 heating season that will allow us to verify his reduction in energy use.
SUPPORTED BY Kansas State Government

1.0105,
INCREASED USE OF SOLAR ENERGY BY COMBINING GREENHOUSE AND ANIMAL SHELTER

C.K. Spillman, Kansas State University, School of Engineering, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (7011-20690-024-A)
OBJECTIVE: Develop, test, and demonstrate increased utilization of solar energy by combining greenhouse and animal shelter for increased insulation and consevation of energy.
APPROACH: Design, construct, operate, and evaluate two indentical 20' x 24' greenhouses attached to the south side of farm buildings. One shall be used as a conrol and attached to an unheated building, the second shall be attached to a hog farrowing house. Air shall be circulated bewteen greenhouse and hog house for use of animal heat and CO(2) enriched air in the greenhouse. Solar heated air in the greenhouse shall be circulated through rock for thermal storage of excess heat. Production and acceptability of tomatoes and cucumbers shall be determined.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0106,
MINIMIZING FUEL REQUIREMENTS FOR DRYING GRAIN

H.H. Converse, U.S. Dept. of Agriculture, Agricultural Research, U.S. Grain Marketing Research Lab., *1515 College Ave., Manhattan, Kansas* 66502 (0040954)
Objectives are to develop drying procedures and equipment that minimize energy requirements, petroleum fuel use and grain damage. Four pairs of tests explored further the potential of using solar energy to dry grain. Three of the paired tests compared drying with solar heated air to drying with natural air. In each test the grain dried with solar heated air dried to a lower moisture content than that dried with natural air in the same length of time. Only minor mold growth was observed in any of the test grains. The fourth test measured the performance of a solar collector with heat storage compared to a tubular collector without heat storage. The heat-storage system, consisting of 30 tons of rock, continued to deliver heat at night. The temperature of the air from rock heat-storage system was normally below ambient only during the hours of maximum sunshine. The collector-storage system accomplished 15% more drying and had 15% higher collection efficiency than the plastic tube solar collectors. A small scale grain dryer heat recovery system in which a heat pump and heat-pipe heat exchanger were combined to recover and reuse heat from exhaust air of a grain dryer was tested. The new energy required to remove water from the grain was reduced 8% using the heat-pipe heat exchanger and 50% using the heat-pipe heat exchanger and heat pump.
SUPPORTED BY U.S. Dept. of Energy

1.0107,
SOLAR ENERGY COLLECTION & BIOMASS GASIFICATION FOR ENVIRONMENTAL MODIFICATION OF LIVESTOCK SHELTERS

B.F. Parker, University of Kentucky, Agricultural Experiment Station, Dept. of Engineering, *Limestone & Euclid, Lexington, Kentucky* 40506 (7005-20400-017-A)
OBJECTIVE: Develop an integrated, multiple-use energy system to heat air for animal structures and for high temperature grain drying using solar-thermal and biomass gasification as energy sources with a rock bed heat storage.
APPROACH: Finalize design of solar collector and rock bed system based upon performance test of the solar collector in both modes of operation and upon results of tests using crushed limestone as a heat storage medium. Construct and test biomass gasifer. Optimize system for heating the swine building and for grain drying.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Atlantic Area

1.0108,
SOLAR ENERGY SYSTEM FOR AGRICULTURE

B.F. Parker, University of Kentucky, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Limestone & Euclid, Lexington, Kentucky* 40506 (KY00129)
OBJECTIVE: Determine the solar radiation concentration, conversion of solar radiation to heat and the heat transfer characteristics of a focusing solar energy collector. Determine feasible outlet temperatures and the corresponding solar energy recovery efficiency of an improved flat plant and focusing solar energy collector.
APPROACH: A focusing collector and a flat plant collector will be constructed-both have unique features which show promise for increasing the collection temperature and/or efficiency. Air will be used initially as the transport fluid with a rock bed for storage. Data from the test will be used to determine the efficiency and output temperature as well as heat transfer characteristics of the collectors. The latter knowledge will be used to improve the design. A computer simulation of the collector, storage and load will be devleoped.
PROGRESS: Progress has been made on solar collector development and on the storage of solar heat in crushed limestone. Theoretical developments from heat transfer analysis in flat plate collectors has led to the derivation of design equations for air-type solar collectors. The results of the first comparative test of three air-type collectors as well as the theory has led to the concept that a vee corrugated absorber plate with the vees oriented in the east-west direction and sloped south will absorb more solar radiation than a plane surface and with air flowing through the resulting triangular ducts formed by the vees provide improved efficiency in collecting solar energy. The focusing collector constructed on the project is currently being used for storing energy in rock beds for use in grain drying. Study of heat transfer between air and rock has led to the development of a computer program for predicting rock temperature as a function of flow and air temperature as well as predicting the heat recovery from rock beds. Verification of the essential relationships in the laboratory and running the computer program has led to the concept that the smaller the stone the greater the heat return above some usable temperature for a rock bed charged from the top and discharged by reverse air flow.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Kentucky

1.0109,
ENVIRONMENT IN GREENHOUSES VENTILATED WITH DEEP MINE AIR

J.N. Walker, University of Kentucky, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Limestone & Euclid, Lexington, Kentucky* 40506 (7095-20690-006A(1))
OBJECTIVE: Evaluate the resulting environment in greenhouses ventilated with deep mine air and determine if deep mine air can be used economically to improve the energy utilization of greenhouses.
APPROACH: Conduct plant growth studies with flowers, vegetables, and woody ornamentals in an existing plastic greenhouse attached to and ventilated from an abandoned mine shaft. Raise similar plants in a conventionally ventilated greenhouse to compare yields, tolerance to various environments, diseases and other production data. Monitor humidity, CO(2) level, solar radiation and other environmental conditions in the mine ventilated greenhouse and vary these factors in the controlled-environment greenhouse to determine their effect on plant growth. Develop and evaluate alternate concepts for utilization of deep mine air such as moving the air between two layers of plastic film to isolate it from the greenhouse and determine the most economic means of utilizing deep mine air for control of greenhouse environments.
PROGRESS: The continuous ventilation of a greenhouse with air in thermal equilibrium with deep ground temperatures to allow dependence on only solar energy for heating and cooling a greenhouse has been studied. Such a concept is approximately 8 times more efficient than conventional greenhouses. Though humidities were high, excellent quality lettuce, chrysanthemums, and radishes could be grown during much of the year. During the mid-winter period when light levels were low, the growth of carnations and selected other flower crops was poor. To reduce the problems with direct ventilation, the movement of ground-conditioned air between an inner and outer layer of glazing and to thereby greatly reduce energy loss during cold days is being investigated. Such a system has the advantage in that if the conditioned air temperature is above an adverse plant temperature, no back-up heating system to a solar system would be required. Such a system theoretically should improve energy efficiency in the winter by a factor of 3 or 4. A one-dimensional heat-transfer model has been developed to describe the energy and mass loss from heated soil beds. This is a particularly attractive use of solar energy since no back-up energy system would need to be supplied to supplement the solar energy when storage depletion occurs. To enhance economic feasibility, insulation concepts to reduce energy loss are being evaluated both theoretically and experimentally.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0110,
CURING BURLEY TOBACCO

W.H. Henson, University of Kentucky, U.S. Dept. of Agriculture Agricultural Engineering Res. Div., Harvesting & Farm Processing Research Branch, *Limestone & Euclid, Lexington, Kentucky* 40506 (7809-20880-002)
OBJECTIVE: Determine the response of Burley tobacco to environmental control of temperature, humidity, and air flow during the early stages of drying; to develop economical curing systems with predictable control of leaf color, chemical change, moisture content, and other physical properties; and to develop curing systems which will facilitate mechanization of harvesting and handling.
APPROACH: Consider the complex biochemical changes in the Burley tobacco plant during curing process. Study plant response (color, chemical change, moisture content, gaseous exchange to curing environment (air velocity, temperature, closeness of packing). Determine degree of leaf damage from adverse environmental treatments; determine degree to which adverse affects of environment may be reversed by subsequent environmental treatments.
PROGRESS: The object was to evaluate the capability of a chamber with solar collector and insulated rockbed and a chamber with solar collector and uninsulated rockbed to reduce high relative humidity during burley curing. The chamber with solar collector and insulated rockbed reduced relative humidity by as much as 17 percentage points while the solar chamber with uninsulated rockbed reduced relative humidity by only 10 percentage points. The insulation is well justified and even more insulation is needed than was used in the insulated rockbed. A mathematical model is being developed to predict the temperature and humidity within tobacco barns during curing as a function of ambient temperature, humidity, wind speed and direction, and solar radiation. Preliminary comparisons show that the one dimensional driving equation predict the relative humidity of the air as it moves through the tobacco to within plus or minus 6% r. h. Results from bulk curing tests indicated that burley can be cured rapidly (8 days or less) without lowering quality as measured by comparison of total alkaloids, total nitrogen, total nitrates, and total sugars from bulk-cured leaf and a stalk-cured check. Moisture sorption and desorption studies indicated that desorption rates were two to three times greater than sorption rates. How-

ever, no differences in rates due to curing treatments were detected
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Atlantic Area

1.0111,
WATER SOURCE HEAT EXCHANGE FOR HEATING AND COOLING IN AGRICULTURAL AND RURAL RESIDENCE USE
H.J. Braud, Louisiana State University, Agricultural & Mechanical College, Agricultural Experiment Station, Dept. of Agricultural Engineering, *University Station, Baton Rouge, Louisiana* 70803 (LAB02061)
OBJECTIVE: Evaluate new thermal energy flow systems with energy exchange to atmospheric, earth, ground water, and fabricated storage media, with solar energy colletion and nocturnal heat refection for use with wate source heat pumps. Survey ground and surface water supplies and soil temperatures in Louisiana for potential thermal energy exchange. Survey existing water-cooled heat pump installations in rural areas to ascertain installation, maintenance, and operating costs and identify operational problems. Evaluate water-source heat pumps and auxillary epuipment for improved energy efficiency in space heating and cooling in rural residence use.
APPROACH: Computer prediction models will be made to quantify energy use in water-cooled heat pump systems with several modes of energy cycling for farmstead and rural residence use. Heat transfer to earth grid, ground water, and surface sources will be evaluated for energy conservation. Laboratory and on-site studies of the more viable heating and cooling systems will be done to verfy computer prediction model.
SUPPORTED BY U.S. Dept. of Agnculture, Cooperative Research Office, Louisiana

1.0112,
DRYABILITY OF HARDWOODS BY SOLAR-HEATED AIR AND ITS RELATIONSHIP TO PERMEABILITY
E.T. Choong, Louisiana State University, Agricultural & Mechanical College, Agricultural Experiment Station, McIntire Stennis Program, *University Station, Baton Rouge, Louisiana* 70803 (LAB01440)
OBJECTIVE: Determine the effect of steaming on permeability and dryability; Construct and evaluate a small forced-air solar dryer for drying hardwoods; relate climatic and solar energy data to drying of wood in Louisiana; compare the results of solar drying with conventional air and kiln drying, in terms of permeability and dryability; develop technique of accelerating the drying of refractory hardwoods with high temperature by first pre-drying in a solar kiln; review the state-of-the-art of solar energy collection and solar drying for application to wood processing.
APPROACH: Determine effect of steaming on permeability, dryability and shrinkage of several species and wood-types; construct a forced-air solar kiln; compile local climatic data relevant to the solar kiln. Dry several species of wood by kilndrying at high and moderate temperatures,, airdrying, and solar-drying. Drying lumber-size material in a drying charge. Review the state-of-the-art of solar drying.
PROGRESS: A small prototype solar hardwood kiln was constructed. Results from 7 experimental dryings indicate that solar drying may be technically sound for drying hardwoods. Boards dried in a solar kiln reached 20% MC in 1/3 the time it took matched air dried samples and were able to reach a lower moisture content. A box-type collector appears to be well-suited to integration into kiln design. Since sufficient heat can be obtained from a small amount of glazing (i.e. low collector/capacity ratio), a kiln heated with a box collector appears feasible on a commercial scale. Further experiments are currently in progress involving more wood species at varying climatic conditions. Effects of permeability on drying rate of several hardwood species was studied by drying samples in an environmental chamber in a two-step drying process. The first study was designed to evaluate the flow of free water and the second study to observe the rate of removal of bound water. Statistical analysis for five species revealed that gas and liquid permeability were highly correlated (P less than 0.01) to weight loss per hour per square centimeter in the first step of drying. In the second step the relationship was also significant but at lower level of probability. However, attempts to correlate drying time from fully saturated condition to the fiber saturation point failed. (Text Truncated - Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Louisiana

1.0113,
SOLAR ENERGY AS SUPPLEMENTARY HEAT FOR GRAIN DRYING
M.M. Mayeux, Louisiana State University, Agricultural & Mechanical College, Agricultural Experiment Station, Dept. of Agricultural Engineering, *University Station, Baton Rouge, Louisiana* 70803 (LAB01890)
OBJECTIVE: Accumulate data on locally available solar energy, and determine efficient methods of collecting and storing this energy for optimum use for grain drying. Determine rates of energy storage and retrieving from a medium such as rock or water under various conditions of air flow and develop management techniques for operating a solar dryer.
APPROACH: Data available from the literature and applicable to grain drying will be accumulated. Additional data needed will be developed. A low cost collector will be constructed and tested. Air flow rates will be varied to optimise heat collection. The production of drying potential (C.F.M. of low RH air) will be measured. A storage bed of rock will be evaluated for energy storage and retrieval. Thermal conductivity, specific heat and surface conductance. Coefficient of Louisiana rock will be determined. A small scale collector, energy storage bed and dryer will be built and tested to determine energy production rates needed for designing solar dryers.
PROGRESS: A circular rock bed 91.5 cm in diameter and 2.44 m deep was filled with 2.54-cm nominal diameter rock. It was instrumented with thermocouples every 15.8 cm. Air was heated with a single glazed collector with an area of 2.6 sq. meters at rates of 1.07 and 1.29 m 3/min/m 2 of collector. The flow of air was vertical. The depth of the bed affects the maximum temperature of the air recovered and the time for the maximum temperature. Using an interstice velocity of 8.32 m/min, the maximum temperature at 101, 127, 152, 178 and 203 cm bed depth occurred at 1740, 1900, 2020, 2130 and 2230 hours. This delays the availability of heat until it is needed during the high-humidity early morning hours. For approximately 8 hours during the middle of the day the ambient temperature exceeds rock bed exit temperature. This, in a large measure, defeats the benefits to be derived from rock storage unless a two-fan system is used. Two model size deep bin dryers were instrumented with thermocouples every 10 cm. Using a flow rate of 0.07 m 3/min/bu, one dryer was fed with a collector and rock storage combination and the other received its air directly from a collector. Rice was used as the test grain. Four drying tests conducted during July and August showed no significant difference in drying time. (Text Truncated - Exceeds Capacity)
SUPPORTED BY Louisiana State Government

1.0114,
UTILIZATION ECONOMICS AT THE REGIONAL RESEARCH LABORATORIES
M.E. Miller, U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div., *P.O. Box 19687, New Orleans, Louisiana* 70179 (NEA-12-107-22-08)
OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for products of the different regions and tneir comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra and inter-regional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.
APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.
PROGRESS: Economic advisory and research services were provided administrators and scientists at the regional research laboratories on the feasibility and consequences of various new technological developments. Contributions of economic services were to (a) an AID sponsored study of market potential of composite flour technology in developing countries, (b) a cooperative study between SEA/AR and Oklahoma State University on model tannery operations, (c) a cooperative study involving SEA/AR, FAS and the National Renderers Association on foreign market potential of tallow-based soap detergents, (d) a cooperative SEA-AR and ESCS assessment of new technologies in cotton processing, (e) a cooperative SEA/AR and ESCS assessment of potentials for additional use of crop residues in cattle rations, and (f) an assessment of feasibility and impacts of solar energy uses in agriculture. The latter three studies are continuing under work unit/Project No. NEA-12-107-11-00. Initial results indicated high fractose corn sweetener was not a perfect substitute for other sweeteners used in manufactured products. An update of the analysis contained in a 1975 report on PRO-XAN indicated commercial feasibility was greatly enhanced by new processing technology. An update of 1975 estimates of cost of producing Kenaf verified its continuing potential as a resource for manufacturing paper.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div.

1.0115,
INTEGRATION & EVALUATION OF FORAGE PRODUCTION, HANDLING, & UTILIZATION
R.J. Rowe, University of Maine, Orono Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Winslow Hall, Orono, Maine* 04469 (ME08034)
OBJECTIVE: Evaluate harvesting and processing systems for immature forages.
APPROACH: Using forage materials harvested at pre-boot and early bud stages as provided by Department of Plant Sciences under companion project, forage will be field cured to approximately 40% moisture, artificially dried at differential temperatures and pelleted. Continuous flow drier will be tested at differential time and temperature rates, pellets evaluated for milling size, durability, and compared with non-pelleted samples, for samples, for nutritional value. Energy requirements will be determined. This is a companion project with Plant Science, Animal Science, and Agricultural Economics to determine feasibility of producing, harvesting, feeding immature silage for ruminants.
PROGRESS: First cut alfalfa plots were cut on June 4 at bud stage. Following approximately 2 days of field drying in sunny but cool weather the wilted forage was dropped at 63% moisture content (wet basis). The chopped alfalfa was dried in bulk at about 3.5 ft depth with 30 cfm per square foot of air. Air was heated by a solar air heater with from 10 to 15 degrees F increase in temperature during midday. Total drying time to 13% moisture content was about 4.5 days including two days of rain. About 1659 pounds was stored for subsequent feeding trials. First cut timothy plots were cut June 15 at mid to late boot stage. Field drying of one day resulted in chopping 62% moisture content. The chopped timothy was dried using the same technique as the alfalfa. About 1175 pounds were stored at 13% moisture content after 5 to 6 days of drying using solar heated air. Input data was prepared for the NE-111 comprehensive forage system analysis model. Equipment was selected by type and size and man and machine operating times and fuel requirements were estimated for the various field operations. These and other cost data used in the model were reviewed and adjusted to correspond to Northern New England conditions.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Maine

1.0116,
SOLAR GREENHOUSE OF BARN COLLECTORS
M.V. Woodward, (No Performing Organization Reported), *Maryland*
SUPPORTED BY U.S. Dept. of Energy

1.0117,
BIOLOGICAL SOLAR ENERGY CONVERSION - APPROACHES TO OVERCOME YIELD, STABILITY AND PRODUCT LIMITATIONS
B. Kok, Martin Marietta Corp., Martin Marietta Laboratories, *1450 S. Rolling Rd., Baltimore, Maryland* 21227 (PFR78-06094)
This award is a sequel to NSF grant AER 73-03291. The overall objective is to assess the feasibility of using photosynthesis for producing energy-intensive substances from renewable resources. The specific objective is to use the energy conversion system of green plants, divorced as much as possible from the other functions of the cell, to produce hydrogen and carbohydrates from carbon dioxide and water.
During this award period, an assessment will be made of the causes of loss of photosynthetic activity after isolation of chloroplasts from leaf cells, and of the differences in electron transport activities among chloroplasts isolated from different leaf tissues. In particular, the role of manganese ions in protecting

chloroplasts from the attack of fatty acids, and the roles of the two photosystems in mesophyll and bundle sheath cells, will be studied.
SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Problem Focused Research

1.0118,
SOLAR ENERGY FOR MILKING PARLOR HEATING AND COOLING

P.D. Thompson, U.S. Dept. of Agriculture, Agricultural Research, Animal Science Inst., Genetics & Management Lab., *Bldg. 173, Romm 209, Beltsville, Maryland* 20705 (0042355)

The objectives are to develop technology and demonstrate the feasibility of using solar energy to reduce the electrical and fossil fuel requirements for operation of milking parlors for dairy production. Solar energy collectors will be specified, procured or constructed, and installed on appropriately modified structures for capture of heat energy. Insulated hot water storage tanks will be constructed to store this energy over diurnal and short-term climatic cycles. Additional heat will be recovered by scavenging waste heat from refrigeration compressors and vacuum pumps. The heat energy thus obtained will be used to reduce the electrical energy required for water and space heating and for milk cooling. System flexibility will be sufficient to accept heat or mechanical energy from wind power if such a project is subsequently established at this location.
SUPPORTED BY U.S. Dept. of Energy

1.0119,
PRINCIPLES OF CONTROLLED ENVIRONMENT PRODUCTION OF CROPS IN SOLAR ENERGY SUPPLEMENTED GREENHOUSES

R.C. Liu, U.S. Dept. of Agriculture, Agricultural Research, Plant Physiology Inst., Light & Plant Growth Lab., *Bldg. 046A, Beltsville, Maryland* 20705 (1109-20191-001)

OBJECTIVE: Obtain information on physical and biological components of a solar powered greenhouse for establishing technical and economical feasibility. Design, construct, test and demonstrate a greenhouse module that uses solar cooling and heating.
APPROACH: Review and compile relevant literature and data in consultation with Federal-State solar energy R/D institutions, solar energy meetings and workshops. Analyze information, synthesize plans, and design a solar greenhouse module. Construct a solar greenhouse module, consisting of collectors, storage and distribution units, and controls. The system will be evaluated in two existing glasshouses at BARC and new modules specifically designed for solar energy. Cooling will be used initially to reduce relative humidity and increase the efficiency of wet pads.
PROGRESS: Design fabrication of and operational procedures for a spectral selective tank chamber have been finalized for commercial contracting. Altogether three such chambers were ordered in two successive deliveries. Growth responses of tomato, soybean, sugarbeet, and lettuce were compared in double-wall tanks filled with either 0.3% CuSO(4), water, or air, and in the greenhouse. Regardless of species, plants grown in the selective chamber produced significantly less fresh weight, even though tomato plants were compact and green while soybean tall and slender. Spectral energy distribution in each chamber where plants were grown has been recorded in cooperation with the Instrument Laboratory.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Beltsville Agricultural Research Center

1.0120,
UTILIZATION OF SOLAR ENERGY IN BROILER PRODUCTION

J.L. Cain, University of Maryland, College Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *College Park, Maryland* 20740 (MD-RAM-49)

OBJECTIVE: Determine fossil-fuel savings by introducing heated air from a solar collector directly into the ventilation air inlet of a broiler facility with excess heat going to rock storage. Retrofit a broiler facility using the roof as a solar collector. Study the physiological response of broilers to determine if introducing heated air from a solar collector significantly affects their behavior or performance. Conduct an economic analysis to determine cost-benefit ratios for the system.
APPROACH: The solar system of the research facility will be modified to replace the water storage of energy with rock storage of energy. The duct work will be modified so that the warm air will enter the ventilation system and/or pass through the rock storage unit. A second test chamber will be modified to add a collector to the roof and take the heated air directly into the ventilation system. Storage will not be provided.
PROGRESS: Following major changes to the solar system in the Fall of 1977 there has been a period of system calibration and minor modifications. Twenty additional points have been added to the data acquisition system. The glass from one-half the conventional system replaced with Tedlar plastic. There appears to be no difference between the two halves in the energy collection capability. Because of back drafts the solar system without storage did not show any savings in energy. Modifications have been completed that should correct this problem. The data collected during this next year should allow performance analysis of these systems.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Maryland

1.0121,
UTILIZATION OF SOLAR ENERGY IN BROILER PRODUCTION

K.E. Felton, University of Maryland, College Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *College Park, Maryland* 20740 (7006-20400-018-A)

OBJECTIVE: To prove the concept of using solar energy with and without energy storage to heat ventilating air of brooding shelters.
APPROACH: Data will be collected from a flat-plate solar collector and rock storage system and from retrofit air collector without storage. Data will be analyzed to compare operation, economy, and feasibility for limited area brooding of broiler chickens.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Atlantic Area

1.0122,
QUALITY HOUSING ENVIRONMENT FOR LOW-INCOME FAMILIES

G.S. Fish, University of Maryland, College Park Campus, School of Human Ecology, *College Park, Maryland* 20742 (MD-Y-011)

OBJECTIVE: Identify housing related aspirations, expectations, needs and satisfactions of low income families and examine limitations to the attainment of quality housing. Develop and determine the acceptability and economic feasibility of innovative designs including housing components, new combinations of materials, and building techniques, such as peripheral heating systems and modular panels.
APPROACH: Two hundred Maryland families living in three bedroom FHA approved houses will be interviewed. Housing characteristics will serve as basis of comparison for innovative design, including housing components, new combinations of materials and building techniques, such as peripheral heating systems and modular panels.
PROGRESS: Research Results and Conclusions - Analysis of the FMHA 502 program in Maryland indicates that over half of the families who had bought a three-bedroom single family home under the program between 1970 and 1975 were paying more than 25% of their take-home pay for housing. The incidence of deficiencies commonly found in housing of rural low-income families approached 0.0 only when the families had take-home pay in the range of twice to four times the poverty level, and the mean of that group in the sample was $12,966. Owners rated the houses lowest on the amount that they were paying for utilities and the amount of storage outside. These three findings suggested that the houses be redesigned with solar heating and hot water systems to reduce the amount to be paid for utilities and the percent of take-home pay spent on housing, and with a garage added for storage space.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Maryland

1.0123,
DEMONSTRATE USE OF COMMERCIALLY AVAILABLE SOLAR HEATING DEVICES TO SUPPLY ENERGY REQUIREMENTS FOR AN OPERATING GREENHOUSE

D.J. Peck, Daystar Corp., *Burlington, Massachusetts* 01803 (EG-77-C-05-5299)
SUPPORTED BY U.S. Dept. of Energy

1.0124,
NORTHWEST REGIONAL ASSESSMENT STUDY

R. Neal, J B F Scientific Corp., *2 Jewel Dr., Wilmington, Massachusetts* 01887 (XP-9-8050-1)

The objective of this study is to identify opportunities for demonstration and follow-on large-scale use of solar electric systems (both central and dispersed) in the Northwest region of the United States, during the time period 1980-2000, for a range of projected technical and economic characteristics for SE and non-solar systems, using inputs from potential owners of solar electric systems. The Northwest region is defined as the states of Alaska, Hawaii, Idaho, Montana, Nebraska, North Dakota, Oregon, South Dakota, Washington, and Wyoming.

This study shall identify (1) potential solar electric options which are expected to be employed in specific segments of the region in the 1980-2000 period; (2) how and when each option might be employed by particular user groups; (3) key demonstrations that need to be taken to facilitate solar electrification in the region; and (4) a strategy for completing the actions, which includes who should take specific actions and the roles of the federal and state governments in facilitating solar electrification.

Solar electric options for the study are photovoltaics, solar thermal electric, wind, OTEC, and biomass.

SUPPORTED BY U.S. Dept. of Energy, Office of Solar Geothermal Electric & Storage Systems

1.0125,
ASSESSMENT OF A SEMI-CLOSED, RENEWABLE RESOURCE-BASED AQUACULTURE SYSTEM

J.H. Todd, New Alchemy Inst. Inc., *P.O. Box 432, Woods Hole, Massachusetts* 02543 (OPA77-16790 A03)

This award is for the final phase of a three-year continuing award (OPA 77-16790) to evaluate the environmental and productivity characteristics of a small-scale, aquaculture system.

This country's aquaculture activities often consume large quantities of nonrenewable resources and are the source of significant non-point pollution. The work at the New Alchemy Institute is an example of scientific experimentation with an alternative or appropriate technology based upon a highly controlled environment, recycling of wastes, reliance upon algae as a food source, and solar energy.

The first two phases of the project saw the installation of physical and chemical data monitoring systems coupled to a unique data acquisition system designed for small-scale use in humid environments. This system measures the water-based components of the food production system. The project has involved several experiments to determine the effects of various feeding regimes on the water chemistry and yield. An ecological model is being developed from these data which is expected to be useful in manipulating productivity and environmental affects in such controlled facilities.

The final phase will involve experimentation with polyculture, use of fresh and live feeds, and ponds linked in a series with water recirculation and trickle flow, and filtration techniques to imporve water quality. The interaction of modeling and experimentation should allow an optimum mix of high fish productivity with low costs for solar-algae pond aquaculture.

SUPPORTED BY U.S. National Science Foundation, Office of Problem Analysis

1.0126,
SOLAR SPACE HEATING AND HOT WATER DEMONSTRATION POND PROJECT

Unknown, Technology Prop. Trust, *Burlington, Massachusetts* 01803 (EG-77-A-02-4409)
SUPPORTED BY U.S. Dept. of Energy

1.0127,
DIRECTLY COUPLED SOLAR THERMAL WATER PUMPING CONCEPTS FOR AGRICULTURE

W. Bornhorst, Thermo Electron Corp., *85 1st Ave., Waltham, Massachusetts* 02154 (ET-78-C-03-1571)
SUPPORTED BY U.S. Dept. of Energy

1.0128,

IMPLICATIONS OF DEMAND, STRUCTURE AND ENERGY CHANGES FOR THE NEW ENGLAND BROILER AND EGG INDUSTRIES

R.L. Christensen, University of Massachusetts, Amherst Campus, Agricultural Experiment Station, Dept. of Food & Resource Economics, *Amherst, Massachusetts* 01002 (MAS00393)

OBJECTIVE: To estimate the energy use and the implications of high cost energy to the production and marketing of broilers and eggs.

APPROACH: Energy input-output parameters will be estimated for broiler and egg operations in the northest using budgeting techniques. Alternative production and marketing systems will be identified and compared with respect to energy use. Alternative energy sources will be examined and evaluated with respect to cost and efficiency. Energy costs will be placed in the context of cost of production and competitive position.

PROGRESS: A study is nearly complete concerning an analysis of the economic feasibility of supplemental solar space heating in New England poultry production. A model solar heating system was described for application to a standardized broiler production unit. Three different sized solar collectors were specified. Energy demand by month was calculated based on historical degree day patterns. Average daily radiation levels were calculated based on weather data for the location and were used in determining heating capacity from the solar heating systems. Five levels of collector cost per square foot were used in the analysis. Variable and fixed costs were determined for the solar system. Each combination of solar collector size, collector cost, fuel inflation rate and general inflation rate was simulated for a 20 year period. Discounted present values of savings were calculated for each situation. Results indicated economic feasibility for the largest collector only when fuel inflation rates were 25% or greater per year and when collector cost was $20 per square foot or less. The smallest collector was found to be feasible when the fuel inflation rate was as low as 10% per year and when collector cost was as great as $35 per square foot. A thesis will soon be completed and an Experiment Station Bulletin prepared.

SUPPORTED BY U.S. Dept. of Agnculture, Cooperative Research Office, Massachusetts

1.0129,

ENGINEERING PROPERTIES OF FOODS IN RELATION TO PROCESSING AND PRESERVATION

L.E. Whitney, University of Massachusetts, Amherst Campus, Agricultural Experiment Station, Dept. of Food & Agricultural Engineering, *Amherst, Massachusetts* 01002 (MAS00417)

OBJECTIVE: Develop theoretical and experimental techniques for obtaining, calculating and predicting engineering data relevant to food production, preservation, storage and handling.

APPROACH: Determine engineering properties and physical chemical properties, modeled systems and in real food materials by mechanical thermaloptical, electrical, chemical and microbiological methods.

PROGRESS: Theoretical analysis of the applicability of mechanical testing methods in solid foods has been carried out. Previously developed rheological models and concepts have been tested with published data on polymers and on actual food materials. Study of mechanical bulk properties of powdered foods has been initiated. Preliminary results of compressibility and relaxation pattern have been obtained. The plasticizing of pasta texture by glycerol and its effect on drying rates and dried product quality has been studied on a laboratory and pilot plant scale. A system of using solar energy in food processing by exploiting water activity differences in CaCl(2) solutions has been developed and designed. Diffusivities of sucrose at various concentrations and temperatures have been determined. Work with other sugars has been started so that the effect of molecular weight in diffusion processes in food could be established. A dielectric heating system for biological fluids has been designed, constructed and operated at various conditions. Comparison of experimental results with model predictions showed reasonable agreement.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Massachusetts

1.0130,

USE OF SOLAR ENERGY PRODUCED WATER ACTIVITY DEFICT FOR FOOD PROCESSING

H.G. Swartzberg, University of Massachusetts, Amherst Campus, Graduate School, *Amherst, Massachusetts* 01002 (7006-2051-022-A)

OBJECTIVE: Investigate economic and technical feasibility of a new energy system based on 'water activity defict' for collecting, storing and using solar energy for food processing purposes, i.e., concentration, cooking, pasteurization, blanching and drying.

APPROACH: Design solar collectors and associated equipment to concentrate calcium chloride and other desiccant solutions, and use such solutions for food processing operations. Use heat of condensation from water absorption of these solutions, as heat source for sustaining evaporation of dehydration of liquid foods such as fruit and vegetable juices. Test possibilities of cascading vapor absorption and vapor generation in a heat pumping effect for moderate low temperature refrigeration, as well as heating. Apply such latent energy from water activity deficts, to evaporating,/concentrating, heating and/or cooking-blanching of fruit and vegetable juices.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0131,

SOLAR ENERGY FOR GREENHOUSE HEATING

W.A. Feder, University of Massachusetts, Amherst Campus, Suburban Experiment Station, *240 Beaver St., Waltham, Massachusetts* 02154 (MAS00429)

OBJECTIVE: This is a joint effort of Federal agencies (ERDA, USDA) State agencies (Agr. Exper. Stn.) and private industry to determine and demonstrate the practical feasibility of growing commercially important plant materials in a greenhouse heated by solar energy systems.

APPROACH: A commercial greenhouse will be retrofitted with solar energy heating units. Data will be collected and analyzed on environmental conditions, energy ratios, collection, distribution and consumption, foliage plant productivity and quality.

PROGRESS: A 4,500 square ft flat plate solar collector free-standing module has been erected using a 10,000 gal water tank for heat storage. The module delivers heat to a 7,500 square ft greenhouse used to produce rooted cuttings for the foliage plant industry. Temperature is controlled by supplementing solar BTUs with fossil fuel generated BTUs'. An identical, adjacent house is heated with only fossil fuel making it possible to measure savings in fossil fuel due to solar BTUs. To date measurements of plant performance have shown no differences due to the type of heat source. At least two or more growing winters will be needed to properly evaluate cost-effectiveness, efficiency, and plant impact in this system. Other systems, devised by interested growers, engineers, and other plant scientists are being prepared for feasibility studies, including the evaluation of green plant performance.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Massachusetts

1.0132,

ENERGY AND AGRICULTURE

F.W. Bakker Arkema, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL01208)

OBJECTIVE: Find ways to beneficially use waste heat from electric power plants in agriculture. The uniqueness of the MSU research does not lie in the subject of the study, but in the approach. Rather than considering the utilization of waste heat in one or two agricultural processes on an experimental basis, the feasibility of an integrated system of a significant number of subsystems is being examined by systems analysis techniques. The result of this research effort should be an analytical tool that can be used to analyze the feasibility of using waste heat from power plants in agriculture.

APPROACH: An optimization technique for determining the best combination of agricultural subsystems for a power plant is being developed. The program has already been used to determine the effect of weather conditions on the best mix of a power plant-fish pond-soil pipe system. During the second year of the project additional subsystems will be modeled and economically investigated. Greenhouse culture, waste treatment and grain drying offer possibilities. Ownership options and financing schemes have to be considered along with the transportation of the waste heat from the power plant to the different subsystems.

PROGRESS: Semi-empirical thin-layer solar drying and moisture absorption equations for corn at low temperature (4-20 degrees C) were developed. The drying and rewetting equations were compared with previously used relationships. The economic feasibility of solar water heating in milk processing plants in the Midwestern Unites States was investigated using the simulation model TRNSYS. The results indicated that for a 20 year payback period it is presently economically justified in large dairy plants to replace 30-40% of the electric energy demand for warm water heating by solar energy. A 1500 ft 2 solar water heating system is being built to verify the simulation results. TELPLAN is a time-sharing computer system for use by farmers and agribusinesses. A particular on grain drying was developed to allow farmers and elevator operators to calculate the energy requirements of their dryers.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Michigan

1.0133,

ANIMAL HOUSING ENVIRONMENT IMPROVEMENT WITH SOLAR ENERGY

M.L. Esmay, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL00981)

OBJECTIVE: Determine the feasibility of solar radiation for the supplemental heating of egg production houses in Michigan. Maintain inside house temperature at from 70 to 75 F rather than the more traditional 50 to 55 F. Dry poultry excreta with hot weather solar energy. Develop a simulation model for the application of solar energy to poultry housing.

APPROACH: A 1200 fg single air pass, fixed-position, glass-glazed solar collector will be evaluated for the suplemental heating of a 5000 laying hen cage-type poultry house. The solar heated air will be introduced directly into the ventilation air system of the laying house as available on sunny days. The solar heated air will help maintain the house temperature at 70 to 75 F and bring about considerable dehydration of the poultry excreta while the sun shines. The excreta drying will hopefully provide a carryover effect that will keep humidity levels within a tolerable range, with reduced air exchange rates during nights and cloudy days. A computer model will be formulated and verified with these data to provide a planning tool for solar collector designs.

PROGRESS: The 10 ft x 110 ft fixed position (south oriented and tilted 30 degrees from the vertical) glass glazed, flat-plate, air-medium, low-temperature solar collector was completed in Mar. 1977 with conventional farm building materials at a cost of $2.63 per sq ft of collector surface. On a clear day in Apr. the collector delivered 750,000 Btu at a 40% efficiency level to the poultry house. This is about 1500 Btu per laying hen housed, and equivalent to about one-fourth of the sensible heat produced by each laying hen per day. Through Aug. and Sep. 1977, the solar collector was operated to dry poultry excreta, as the heat was not needed for supplementary heating. A research project on calf housing moisture content used 2 calorimeter-type enclosures, each housing 11 calves to develop the following conclusions. The total stable heat production of Holstein bull calves in tie stalls bedded with fresh wood shavings every 2 days decreased on a unit body weight basis with increasing weight. Heat production at 50 kilogram weight was 3.1 Kcal/hr-kg while at 65 kilograms heat production declined to 1.7 Kcal/hr-kg. Total stable heat production did not change for tests conducted.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Michigan

1.0134,

SUPPLEMENTAL HEATING OF LAYING HEN HOUSES AND EXCRETA DRYING IN THE NORTHERN STATES WITH SOLAR ENERGY

M.L. Esmay, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (7091-20401-011A)

OBJECTIVE: Develop and evaluate techniques for use of solar energy for supplemental heating of cage-type egg production houses in the northern states in winter, and for drying of poultry excreta produced in such houses in both summer and winter.

APPROACH: Solar energy collection system will be installed on caged layer research house to increase winter environmental temperature in house from 55 to 70 F. in order to reduce feed consumption, reduce ammonia and moisture in house, and enhance drying of manure. Solar system will be used in summer to increase drying of manure produced in houses.

PROGRESS: The 10 ft x 110 ft fixed position (south oriented and tilted 30 degrees from the vertical) glass glazed collector was operated during the winter of 1977-78 for providing supplemental heat as available to a 5000 bird, cage type egg production house. The solar collector, if found to be feasible, should be retrofitted to the poultry and livestock buildings to minimize cost and heat loss was constructed separately from the existing poultry house as it was oriented improperly. On a clear day in April the collector proved capable of delivering 750,000 Btu to the poultry house. This was an efficiency of about 40% based upon the total amount of solar energy available to the collector. During August and September, 1977, the solar energy from the collector was directed into an excreta drying tunnel adjacent to the house. The average daily excreta produced by 5000 laying hens was 1255 lbs at 80% moisture. Some 325 lbs. of water daily was removed from the excreta in the drying tunnel equaling about one-third of the total water available.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Alabama - North Mississippi Area

1.0135,
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
H.C. Zindel, Michigan State University, Agricultural Experiment Station, Dept. of Poultry Science, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL01064)
OBJECTIVE: Develop optimal animal manure management systems to meet evolving environmental and economic requirements and be compatible with increasing needs for animal protein. Characterize atmospheric contaminants and develop abatement methods to eliminate contaminants potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses. Characterize non-point population water runoff sources from livestock and poultry enterprises on pasture production systems and land areas with manure application and further develop guidelines for abatement of non-point pollution sources from animal manures.
APPROACH: Waste management systems presently employed in Michigan will be monitored and evaluated for improved design for machinery management technique and collection alleyways. Determine the influence of feeding an odor suppressant to broilers and laying hens in relationship to feed efficiency, weight gain, and fecal odors. Study of anaerobic organisms in poultry anaphage. Upgrading the crude protein of anaphage. Study the calcium and postasium availability from poultry anaphage. Study the amino acid availability by employing turn-over rate estimates, involving radio labeled amino acids.
PROGRESS: A flat-plate 110m 2 solar collector was used for supplemental heating of ventilation air entering a poultry layer house. This supplemental heat made it possible to maintain higher in-house temperatures in Michigan without temperature stratification. Further work is underway to establish the humidity gradient across the house.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Michigan

1.0136,
SOLAR HEATING PANEL - PARKS AND RECREATIONAL BUILDING
Unknown, Saugatuck Township Park & Recreation Commission, *Box 631, Saugatuck, Michigan* 49453
SUPPORTED BY U.S. Dept. of Energy

1.0137,
APPLICATION OF SOLAR ENERGY TO TEXTILE DRYING ITEM 24 - 246
E.G. Zoerb, Honeywell Inc., *2600 Ridgeway Pkwy. N.E., Minneapolis, Minnesota* 55413 (EY-76-C-05-5124)
SUPPORTED BY U.S. Dept. of Energy

1.0138,
ASSESSMENT OF ENGINEERING PARAMETERS IN ENVIRONMENTAL DISEASE INTERACTIONS
K.A. Jordan, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *St. Paul, Minnesota* 55101 (MIN-12-079)
OBJECTIVE: Develop systems of temperature, humidity, dust and pathogen for field use. Determine required ventilation rates to effect fuel savings by litter management for uniform conditions. Collect homeothermic data for prediction of environmental influences.
APPROACH: Environmental-disease experiments will be conducted cooperatively to assess environmental factors. Effective conductivity of litter will be determined and litter vaporization used to provide management flexibility of litter. Respiration calorimetry will be used with varying environmental conditions.
PROGRESS: Animal studies with calves, pigs, and turkeys indicate the need for new minimum ventilation standards for energy conservation. 80 calves, four pens replicated minimum airflow rates, 4AC/Hr and 1 AC/Hr demonstrate calf response to pneumonia adversely affected by low airflow rates. Lung lesions differences were dramatic. Data to determine influence of stock area on turkey mortality and profitability digitized and sorted. Statistical analysis in progress. Experimental vertification, turkey simulation model in progress. Turkey heat production data summarized. Heat exchanger experiments underway for fouling and economics. Liquid and air-type solar projects to assist ventilation in turkey barns. One cubic meters of rock storage for each cubic meter per minute of air produces a 12-hour lag in temperature pattern for air systems in simulation, experimental evidence being collected.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Minnesota

1.0139,
BIO-PHYSICAL FACTORS AFFECTING ENERGY REQUIREMENTS FOR POULTRY PRODUCTION
K.A. Jordan, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *St. Paul, Minnesota* 55101 (MIN-12-075)
OBJECTIVE: Develop a model to evaluate the manipulation of biological and physical systems needed to reduce feed and fuel energy costs. This will be accomplished by assessing the interactions between biological factors such as: Metabolism, nutrient, behavior, reproduction, endocrine factors, infection, and physical factors such as: Thermal environment, light, air quality, and confinement. Develop and evaluate new techniques for measuring physiological and behavioral responses to the environment.
APPROACH: Biological models are being verified by calorimetric tests, nutritional trials, and body composition analysis. Biological causes and constraints will be considered. Physical models including simulation of solar energy sources and perimeter losses of the building will be verified and exercise to determine viable systems. Ventilation rates are to prime importance in establishing energy efficient systems that are cost effective. Thus field tests of numerous systems will be used to document how ventilation should be managed.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Minnesota

1.0140,
DRYING HIGH MOISTURE SEED AND GRAIN TO ENHANCE QUALITY AND MARKETABILITY
A.H. Boyd, Mississippi State University, Agricultural & Forestry Experiment Station, Dept. of Agronomy, *102 Experiment Station Bldg., Mississippi State, Mississippi* 39762 (MIS-6219)
OBJECTIVE: Develop techniques for drying forage crop, soybean and small grain seeds for maximum seed quality and marketability. Applications of solar energy to replace fossil fuels in drying applications. Evaluation of single and multiple screw stirring devices as they affect rate and uniformity of seed drying.
APPROACH: Determine heat tolerance, maximum rate and moisture/temperature relationships for soybeans, bahiagrass and selected cereal seeds. Emphasis on solar energy will be for adaptave research (technical and economic) and utilization of solar heat or maximum replacement of fossil fuel on a practical basis. Evaluation of mechanical stirring devices will be done primarily with co-operating farmers and manufacturers because large masses of material are needed for proper evaluation for drying rate and uniformity.
PROGRESS: Soybeans were found to tolerate drying temperatures up to 54.4C for three hours without appreciable loss in germination if air flow and drying were uniform. Germination decreased rapidly at temperatures above 54.4C with 65C for one hour sufficient to lower germination by 10%. Hardseeded soybean lines were found to lose moisture at a slower rate than normal seedcoat seed dried under otherwise identical conditions. Hardseeded lines harvest at 18% moisture and artificially dried had significantly higher percentages of hard seed than when dried in the field.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Mississippi

1.0141,
SOLAR DRYING OF PEAT
R.W. McClendon, Mississippi State University, Agricultural & Forestry Experiment Station, Dept. of Agricultural & Biological Engineering, *102 Experiment Station Bldg., Mississippi State, Mississippi* 39762 (7005-20190-017-A)
OBJECTIVE: Design, construct and test a solar dryer to dry peat economically to a marketable moisture content.
APPROACH: A fiberglass greenhouse-type structure will be erected over a concrete slab. Peat will be spread to specific uniform depths and dried by solar energy. Electric fans will be used to remove the moisture-laden air from the structure. All conditions within the greenhouse will be monitored and moisture content will be measured at intervals. A mathematical model of the system will be used to make economic projections.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0142,
ADDITION OF SOLAR AIR HEATERS TO PRE-ENGINEERED METAL BUILDINGS
R. Forbes, Mississippi State University, School of Engineering, Dept. of Mechanical Engineering, *Suite 101 Engineering Bldg., Mississippi State, Mississippi* 39762 (EG-77-G-04-4086)
Proposed is the modification to an existing pre-engineered metal building which presently has 480 square feet of solar air heaters installed on the south wall. Material cost for this collector was 60 cents/square foot. The 30 by 48 foot building is currently being operated as a solar heated poultry house where ambient air is pulled into the collector, routed to the house or a rock storage bed, and is finally exhausted to ventilate the house. The ventilation, although wasteful from an energy standpoint, is required in all livestock shelters. Modifications will be performed on the present collector system so that air from the heat structure can be returned to the collectors in a recirculation mode. The building will be available at no cost to the proposed research, with only minimal expenses associated with conversion from once-through heating to the recirculation mode. Instrumentation requirements will be analyzed and necessary changes made in the existing data recording system. Data will be recorded on a continuous basis during the heating season 1977-78. Auxiliary heating requirements will be met by a central propane furnace. Propane consumption will be measured by monitoring the weight of propane consumed during a given test. (DOE/CS-0010)
SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Div. of Solar Energy, Office of Solar Application for Buildings

1.0143,
GRAIN DRYING AND CONDITIONING: REDUCTION OF USE OF PETROLEUM PRODUCTS
D.B. Brooker, University of Missouri, Columbia Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *130 Jesse Hall, Columbia, Missouri* 65201 (MO-00073)
OBJECTIVE: Modity the procedures used to dry grain so that a minimum of petroleum products are used, develop methods of using and storing solar energy for grain drying, and utilize Missouri weather data in developing controls and procedures for grain drying that reduce petroleum product use.
APPROACH: Simulation coupled with laboratory tests will be used to carry out the research. Laboratory data will check the validity of the simulations and provide input data for new models. Hourly weather data, available from the Department of Atmospheric Science, will be used in the simulation.
PROGRESS: A comprehensive compilation of test data of thin layer drying and thin layer rewetting of shelled corn has been completed. In all, data for 813 tests, consisting of 16,672 observations, have been compiled for drying. Data for 14 tests, consisting of 401 observations, have been compiled for rewetting. Equations, based on all the data compiled, were developed to express thin layer drying and rewetting of shelled corn. The equations are simple but contain pertinent independent variables. The equations are useful in the simulation of all deep bed drying

systems. The data have been compiled in tables that list measured values of moisture and values of moisture predicted by the developed equations as a function of time. Each table is coded to give the data source, the initial corn moisture, the air velocity and the temperature and humidity of the drying or rewetting air. An apparatus has been assembled to study heat storage in a low melting point eutectic (salt) in plastic trays. No data have been collected. The advancement in technology, equipment and management of on-farm grain drying in the past 30 years was reviewed. These developments, as well as the present status of on-farm grain drying, are presented in ASAE Paper 78-3007.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Missouri

1.0144,

OPTIMIZATION OF SOLAR ENERGY FOR MODIFICATION OF SWINE FARROWING HOUSE ENVIRONMENTS

K.L. McFate, University of Missouri, Columbia Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *130 Jesse Hall, Columbia, Missouri* 65201 (12-14-7001-555)

Solar energy facilities are being installed in a new swine research unit on the University's farms. These facilities will be used to evaluate several methods of applying solar energy to swine farrowing and brooding, and determine the amount of conventional energy reduction resulting from solar energy use in closely controlled swine research studies.

SUPPORTED BY U.S. Dept. of Energy

1.0145,

ENERGY UTILIZATION AS RELATED TO FARMSTEAD MECHANIZATION, MATERIALS HANDLING, AND RURAL LIVING

K.L. McFate, University of Missouri, Columbia Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *130 Jesse Hall, Columbia, Missouri* 65201 (MO-00077)

OBJECTIVE: Investigate feasibility, performance, costs, benefits related to optimum use of electricity (independently and/or in combination with other forms of energy, especially solar) as such relate to: improved crop and livestock production facilities, handling and preservation of food products, and the effects of energy reductions and/or conservation in rural Missouri.

APPROACH: Determine optimum drying of grain (soybeans) with minimum energy input via field test. In cooperation with animal scientists, energy factors related to different building-production-facility systems will be determined. A combination solar energy-heat pump system will be installed and evaluated for use as major heat source in a farrowing house to determine design parameters and limitations.

PROGRESS: Preliminary results of using a low-cost solar-assist heat pump (over conventional unit) indicated a 25 to 30% energy savings in average heating season at Columbia, Mo. For the 2450 sq ft area (two floors) of home, this meant $100 to $120 savings with electricity at 4 cents/kwhr. Material cost for constructing and adapting the remotely-located solar collector and storage system to the existing home was approximately $2500. L. L. Christianson, with R. M. George, developed a low-cost digital electronic device for measuring the thermal resistance of structural walls. A patent search has been completed and negotiations with possible manufacturers is underway. The long-term impact on energy conservation in farm, residential and commercial structures can be phenomenal. Financial assistance for this project was enhanced with a $5000 increase in private industry support for on-going applied energy conservation and management research. In a study of different low-cost solar heat-energy storage devices, soda pop cans filled with water proved better than either rock or plastic milk jugs because of less pressure drop with air transfer. High heat capacity and good heat transfer were associated with the pop can storage. Developed computer model which predicts feed consumption within 4% and finish weight of hogs within 1% of measured values accounting for temperature and humidity effects.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Missouri

1.0146,

ENERGY USE IN MARKETING AND PROCESSING FOOD AND FIBER COMMODITIES

K.C. Schneeberger, University of Missouri, Columbia Campus, U.S. Dept. of Agriculture Commodity Economics Div., Poultry Products Program Area, *130 Jesse Hall, Columbia, Missouri* 65201 (CE-08-077-29-01-X1)

OBJECTIVE: Develop estimates of energy required in marketing food and fiber commodities, present and future. Conceptualize and develop analytical models for aggregating and disaggregating energy data and studying alternatives relating to enery forms, locational, geographical and seasonal problems, commodity shifts, and long-range programs. Analyze potential energy use with alternative marketing methods, new technology, and conservation practices. Determine effects of modification of regulations on energy use by agricultural marketing firms and of national and international energy policies on costs, prices, location of production and marketing functions, and commodity mix. Suggest policy alternatives which would maintain a viable agriculture.

APPROACH: Develop estimates of energy use in the marketing of selected food and fiber commodities. Conceptualize and test and accounting model for measuring energy use in agricultural marketing and evaluate potential energy requirements with alternative marketing systems. Estimate State energy requirements for marketing by type of energy, season, commodity and function. Study effects of modified transportation and environmental regulations. Develop structural profiles of agricultural marketing firms with inputs and cost measurements.

PROGRESS: Available energy data and studies were reviewed. Schedules and plans for survey of energy use, conservation, and practices in marketing all food and fiber commodities were completed and analysis was begun. A framework for marketing energy data base was developed. A report on energy use and costs in Southern broiler processing plants was published. Data on energy use and costs in rendering poultry products was analyzed and a report was published on solar grain drying systems.

SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Commodity Economics Div.

1.0147,

EQUIPMENT AND CONSTRUCTION MATERIALS TO MEET ENVIRONMENTAL DESIGN CRITERIA FOR LIVESTOCK FACILITIES

G.R. Bodman, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Lincoln, Nebraska* 68508 (NEB-11-043)

OBJECTIVE: Test especially designed and constructed buildings and collect mass flow data for heat and moisture. Design buildings for better energy use in animal production. Use simulation models for optimizing beef, swine and dairy production facilities.

APPROACH: Multi-cooperative agreements for mutual benefit of industrial suppliers of buildings, building materials and equipment; farm producers; and University and USDA research personnel will be developed to study and evaluate innovative structural design and equipment. Buildings constructed will be evaluated for the economy of design related to benefits derived from environmental control. Simulation models are to be extended to relate use of solar energy, recovery of latent heat of vaporization, and similar innovations to the production economics.

PROGRESS: This project is directed at studying the utilization of solar heat from both active and passive collectors to improve animal performance in a modified-open-front (MOF) swine growing-finishing house. An in-floor distribution system conveys warm air from the active collectors to the floor-soil mass heat storage system. Data gathered during the early 1978 heating season indicate that the solar collectors are effective in providing higher animal-zone temperatures. Additionally, the floor-soil mass storage provides more uniform temperatures in the animal zone. However, tests to date have not shown a direct influence in the form of better pig performance as a result of the higher temperatures. The combination of an active solar collector and warm floors has eliminated the need for additional supplemental heat for pigs over 18-20 kg. The data indicate that where vertical ducts are utilized to convey solar heat from the collectors to the point of use, baffles are required to control convection currents during periods when fans are not operating. Failure to do so results in floor cooling due to net radiation losses through the collectors. Preliminary studies suggest that flush water and a heat exchanger can be used to cool the animal zone during warm weather. The significance of these findings has not been determined. Additional studies are planned during the forthcoming cooling season.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Nebraska

1.0148,

USE OF SOLAR ENERGY IN A MODIFIED OPEN-FRONT SWINE FINISHING UNIT

J.A. Deshazer, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Lincoln, Nebraska* 68508 (7099-20400-010A(4))

OBJECTIVE: Determine the feasibility of using solar energy for substitution of fossil fuel in heating swine finishing shelters, to develop solar collectors which will perform the dual function of collecting solar energy for heating ventilation air and reclaiming heat from exhaust ventilation air.

APPROACH: A swine production house will be equipped with specially designed solar collectors which will heat ventilation air with solar energy and reclaim latent and sensible heat from exhaust ventilation air. Comparison will be made between the experimental unit and a conventional production unit.

PROGRESS: A bio-physical computer model was developed to predict the effect of solar heating on the performance of growing-finishing swine and swine buildings. Simulation runs have indicated that for a growing-finishing building with a passive or active collector, a collector/floor area ratio should be 0.5 in Nebraska. The use of passive solar heating with no other supplemental heating decreased the amount of feed required per unit gain by 3%. When supplemental heating was employed, the solar heating system reduced the supplemental fuel requirement by 6.7%. A modified open front (MOF) building for housing 360 pigs was constructed for evaluating solar heating systems on a commercial farm. The 39.0 m X 9.1 m MOF building was constructed with two 1.2 m X 17 m active solar collectors being erected perpendicular to the shed roof to receive additional reflected solar heat from the roof. The collectors were mounted with a 25 cm spacing between the roof and the bottom of the collector which allowed for the clearing of snow. In conjunction with the active collector, a two 4 m X 18 m concrete block floor heat storage unit was formed. A passive collector, 3 m X 36 m was utilized. During the summer, night air and night air colled by negative radiation through the solar collectors were used to decrease floor temperature. This caused a 50% to 150% increase in the heat conducted from the animal through the floor to the storage unit. However, there were no consistant results favoring the use of floor cooling by the solar system.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Alabama - North Mississippi Area

1.0149,

PLANNING FARMSTEAD BUILDINGS AND LIVESTOCK PRODUCTION SYSTEMS

D.D. Schulte, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Lincoln, Nebraska* 68508 (NEB-11-003)

OBJECTIVE: Participate in programs established by North Central Regional agreements for cooperative effort in furthering research work, plan development, and bulletin publications pertaining to farmstead buildings and their related equipment and livestock production systems.

APPROACH: State cooperation in regional programs is important for the development and maintenance of good plans and bulletins pertaining to farmstead structures and related equipment. Each cooperating state sends two staff members to annual planning meetings. At these meetings sub-committees are appointed for the next year. These sub-committees develop plans, bulletins, etc. on their appointed subject area. Midwest Plan Service headquarters coordinates work. The sub-committee's work is reviewed by staff members in each cooperating state. The material is then printed for distribution to state extension agencies, farmers, equipment dealers, or any interested individual.

PROGRESS: The development of materials by the Midwest Plan Service in the form of plans, publications, handbooks and technical data sheets for use by designers, suppliers, producers and homeowners was continued during the year. An emphasis of many of the publications was home food production and energy conservation. Conservation was stressed as a requirement of both design and management. Progress was also made in the development and refinement of programs for use with the Agnet computer network which is active in Nebraska, South and

North Dakota, Montana, Wyoming, Colorado and Kansas. Programs developed during the past year with direct impact on this project are: House--Home energy audit plus management recommendations. Solswine--Simulates effectiveness of solar collector systems for swine production units and predicts pig performance. Ductlocation--Sizing and spacing of air ducts for flat grain storages plus calculation of fan requirements. Fansize--Calculates fan size for natural-air grain drying systems. Fanmatch--Estimates airflow rates when a fan is matched to a specific bin and air duct arrangement. Beef--Predicts beef animal performance for various feedlot, ration and temperature conditions. Confinement--Predicts swine performance, ventilation and supplemental fuel requirements for environmentally regulated production units.
SUPPORTED BY Nebraska State Government

1.0150,
SOLAR ENERGY FOR DRYING CORN IN U.S. PRODUCING AREAS
T.L. Thompson, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Lincoln, Nebraska* 68508 (3090-15705-022-A)
OBJECTIVE: Determine through computer simulation, the relative effectiveness of solar energy for in-storage drying of corn in the principal U.S. corn producing areas.
APPROACH: Using available historical weather data, determine the effect of solar energy when used with in-storage drying systems on the total energy required and on overall drying costs. Various management strategies involving different levels of heat supplementation, fan operating schedules, harvest dates and moisture contents will be evaluated. Guidelines will be developed for managing low-temperature drying systems for 3 harvest dates and 3 moisture levels at selected locations. Probabilities of successful drying will be based on reducing corn moisture levels to 15 percent with 0.5 percent, or less, dry matter loss.
PROGRESS: University of Nebraska - Additional simulation runs were completed for central Iowa conditions studying various fan operation schedules, levels of solar and supplemental heat and spring drying periods. A similar series was begun for Indiana conditions. Tables showing the probability of various temperatures and equilibrium moisture contents were generated for one location in each state in the North Central Region for use in defining winter periods when natural air does not accomplish drying.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Kansas - Nebraska Area

1.0151,
TEMPORARY STORAGE OF HIGH-MOISTURE FEED GRAINS
T.L. Thompson, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Lincoln, Nebraska* 68508 (NEB-11-034)
OBJECTIVE: Study, through mathematical modelling and experimental verification, the conditions that exist during the temporary storage of high-moisture feed grains, including identification of active microorganisms.
APPROACH: Mathematical models will be developed to predict the conditions that exist during the temporary storage of high-moisture feed grains both in confined grain storage structures and in piles of grain. Field research will be conducted to provide experimental testing of the accuracy of the mathematical predictions and to allow identification of the types and strains of microorganisms that thrive under those conditions and their level of activity, with special emphasis on toxin producing microorganisms. Grain samples taken periodically will be evaluated for grade, foodstuff analysis, feed value, and toxicity. The models developed will be used to evaluate many temporary grain storage practices.
PROGRESS: Evaluations continued to determine the minimum airflow rates required for natural and low temperature (solar and continuous heat) grain drying. Minimum airflow recommendations were completed for 16 locations representing the corn producing areas of the U.S. and a range of moisture contents and harvest dates. Each recommendation is based on 10 years of actual weather data. Airflow rate is the most important factor when setting up a system and generally it cannot be reduced by adding supplemental heat. Management simulation runs have been completed for 6 of the locations to evaluate--on a performance and an economic basis--the effect of several fan and heater operating strategies. Results indicate overdrying problems and high airflow requirements for moisture contents above 22% w.b. Layer drying was investigated as a method of increasing drying potential. Layer drying results indicate the maximum moisture content grain that a specific system can handle can be increased 1 to 2% w.b. for each additional week in the bin loading operating. The results are dependent on the specific bin setup and the interval between equal sized loads. Airflow reversal, recycling and stirring were studied as possible solutions to overdrying. The results indicate stirring reduces the total drying time required and reduces overdrying. An economic evaluation of stirring is needed.
SUPPORTED BY Nebraska State Government

1.0152,
SOLAR HEATED FLOORS FOR NURSERY PENS IN SWINE FARROWING BARN
C. Baggett, (No Performing Organization Reported), *Nevada*
SUPPORTED BY U.S. Dept. of Energy

1.0153,
SOLAR ASSISTED FISH HATCHERY
Unknown, Pyramid Lake Indian Tribe, *Satcliffe, Nevada* 89510 (EM-78-G-03-1981)
SUPPORTED BY U.S. Dept. of Energy

1.0154,
SOLAR HEATING SYSTEM WITH A GAS HEATING SYSTEM FOR MAXIMUM EFFICIENCY COMPARED TO A WOOD STOVE/SOLAR COLLECTOR COMBINATION
Unknown, Sierra Nevada College, Undergraduate School, *P.O. Box 4269, Incline Village, Nevada* 89450
SUPPORTED BY U.S. Dept. of Energy

1.0155,
ENERGY USE IN MARKETING AND PROCESSING FOOD AND FIBER COMMODITIES
G.E. Frick, University System of New Hampshire, University of New Hampshire, U.S. Dept. of Agriculture Commodity Economics Div., Poultry Products Program Area, *Durham, New Hampshire* 03824 (CE-08-077-33-01)
OBJECTIVE: Develop estimates of energy required in marketing food and fiber commodities, present and future. Conceptualize and develop analytical model for aggregating and disaggregating energy data and studying alternatives relating to energy forms, locational, geographical and seasonal problems, commodity shifts, and long-range programs. Analyze potential energy use with alternative marketing methods, new technology, and conservation practices. Determine effects of modification of regulations on energy use by agricultural marketing firms and on national and international energy policies on costs, prices, location of production and marketing functions, and commodity mix. Suggest policy alternatives which would maintain a viable agriculture.
APPROACH: Develop estimates of energy use in the marketing of selected food and fiber commodities. Conceptualize and test and accounting model for measuring energy use in agricultural marketing and evaluate potential energy requirements with alternative marketing systems. Estimate State energy requirements for marketing by type of energy, season, commodity and function. Study effects of modified transportation and environmental regulations. Develop structural profiles of agricultural marketing firms with inputs and coast measurements.
PROGRESS: Available energy data and studies were reviewed. Schedules and plans for survey of energy use, conservation, and practices in marketing all food and fiber commodities were completed and analysis was begun. A framework for marketing energy data base was developed. A report on energy use and costs in Southern broiler processing plants was published. Data on energy use and costs in rendering poultry products was analyzed and a report was published on solar grain drying systems.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Commodity Economics Div.

1.0156,
IMPACT OF INCREASED ENERGY COSTS ON THE NEW JERSEY GREENHOUSE TOMATO INDUSTRY
P.S. Dhillon, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, Dept. of Agricultural Economics & Marketing, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (NJ00886)
OBJECTIVE: Analyze the effects of increased fuel prices on the New Jersey greenhouse tomato industry; determine the cost of construction and operation of a solar-heated greenhouse, along with the resultant savings in fuel expenditures and production costs; estimate the level of fuel prices at which solar energy would become competitive with fossil fuel.
APPROACH: The impact of increased fuel prices on the industry will be determined by analyzing the trends in production and number of greenhouse operations in the state. Profitability of using solar heat will be determined by budgeting costs and revenues for a model operation.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New Jersey

1.0157,
HEATING GREENHOUSES WITH SOLAR ENERGY
D.R. Mears, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, Dept. of Biological & Agriculture Engineering, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (7006-20690-019-A)
OBJECTIVE: Evaluate and refine research prototypes of solar heating greenhouse systems using solar heated water and investigate methods for reducing greenhouse energy use, and low-energy methods of cooling greenhouses.
APPROACH: Continue evaluation of a 13'x28' solar-heated water collector module used to heat a 17'x24' greenhouse. Design, test, and evaluate three 13'x96' solar-heated water collectors each utilizing different framing materials, wood, steel, and aluminum. Use these collector modules to heat water to be stored in three types of floor storage systems, 9'-deep gravel floor with no concrete cap, 9'-deep gravel with porous concrete cap, and 12'-deep gravel floor with walkways only having a porous concrete cap. Modify a 26'x30' greenhouse to test cooling by using movable plastic-film curtains and water films to extract surplus heat from a greenhouse attic and store it in the floor systems.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0158,
DEVELOPMENT OF A CLIMATOLOGY OF SOLAR RADIATION INCIDENT OF SLOPING SURFACES IN THE MID-ATLANTIC STATES
N.M. Reiss, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, Dept. of Meteorology & Physical Oceanography, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (NJ00282)
OBJECTIVE: Develop a climatology of solar radiation incident on sloping surfaces that can be used in the design of solar collectors for the mid-Atlantic region of the United States; attempt to improve existing techniques for parameterizing the diffuse component of solar radiation.
APPROACH: Simultaneous measurements of the direct and diffuse components of solar radiation made over a limited period of time at Maplewood, NJ will be used to test the applicability of several existing techniques for estimating these quantities. Modification in the estimation techniques will be made as suggested by the results of these tests. Tables that give estimates of solar radiation indident on surfaces of various slopes will be produced.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New Jersey

1.0159,
ENGINEERING GREENHOUSE SYSTEMS AND ENVIRONMENTS
W.J. Roberts, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, Dept. of Agricultural & Biological Eng, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (NJ00556)
OBJECTIVE: Improve the engineering and horticultural aspects of greenhouse vegetable production systems adaptable to year-round production under New Jersey condition and determine the impact of an expanded industry of this type.

APPROACH: Models and full size prototypes of selected structural systems will be designed, built, tested and evaluated. Various automatic controls for maintenance of growing crops will be studied from an engineering and horticultural standpoint. Steaming systems will be designed and tested. Soluble salt, ammonium and nitrate toxicity problems will be evaluated by soil test procedures. The possibilities of utilizing waste heat from industrial operations for greenhouse vegetable production will be studied. The role of a year-round vegetable greenhouse industry in the community will be examined. The concern to costs and returns, land and other resource utilization (including labor needs) and impact of such an industry on the environment.

PROGRESS: A functioning solar-assisted heating system has been built and is being tested. Components include a 17' x 24' slant-leg, double-covered, air-inflated polyethylene greenhouse, a 13' by 28' Rutgers polyethylene solar collector, a 15.7' by 12.2' by 9' porous, concrete-capped gravel floor for heat exchange and storage, an insulating black polyethylene curtain, two 20' by 5' polyethylene vertical curtain heat exchangers, a 200', 1' diameter polyethylene pipe heat exchange loop installed in the gravel for supplemental fossil fuel heating, a hot water boiler and automatic controls. A fall crop of greenhouse tomatoes is being grown to determine if the warm floor is affecting the plants. The system is working very well and the solar contribution to the energy requirement is substantial. A 36' by 48' greenhouse is being modified to conform to commercially available gutter-connected structures 3 bays wide. A vinyl liner was installed in the floor using a technique developed for retrofitting existing greenhouses that have interior posts. A composite floor is being installed in stages so the parts can be studied individually. A heat-saving curtain system has been installed to heat several different materials. Tests are being conducted with small solar collectors in an effort to improve the efficiency of the absorber surface and achieve complete absorber surface wetting with minimum pump horsepower.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New Jersey

1.0160,

NUTRITION, DISEASE AND MANAGEMENT OF LIGHTWEIGHT FEEDER CATTLE

A.B. Nelson, New Mexico State University, Las Cruces Campus, Agricultural Experiment Station, Dept. of Animal Range & Wildlife Sci, *University Park, Las Cruces, New Mexico* 88003 (NM04108-1)

OBJECTIVE: Plan and construct a facility for studying nutrition, disease, and management of lightweight feeder and stocker cattle; compare certain nutrition, disease, and management procedures in backgrounding programs.

APPROACH: Acquire land and plan and construct facility. Compare wheat pasture vs. drylot, type of supplemental feed for lightweight cattle, and kind and time of inoculation if facilities are available during the third year (25 head per lot and replicated).

PROGRESS: Construction is complete on a feedlot (48 feeding pens, sorting pens, holding pens, sick pens and scale) and a 70' x 70' building for working cattle (crowding chute, squeeze chute, scale and dipping vat). The center pivot sprinkler system will be operational upon completion of the irrigation well. Funds have been allocated for solar-heated residence, an office-laboratory building and a 40' x 120' storage shed-shop building. Two short-term feeding trials have been completed. Average daily gain and feed efficiency of yearling steers were not affected by level of protein (8.5 or 11.0%) in the ration but implanation (Synovex) increased gain 20% and improved feed efficiency 17%. Weaner calves gained 48% faster and 29% more efficiently for 26 days when fed a high energy (75% concentrate) ration. Calves processed immediately upon arrival to the feedlot gained 22% faster and 20% more efficiently than those processed one week after arrival.

SUPPORTED BY New Mexico State Government

1.0161,

UTILIZATION OF SOLAR ENERGY AND THE DEVELOPMENT OF AN EGYPTIAN VILLAGE - AN INTEGRATED FIELD PROJECT

E. Lumsdaine, New Mexico State University, Las Cruces Campus, School of Engineering, Dept. of Mechanical Engineering, *University Park, Las Cruces, New Mexico* 88003 (INT78-01126)

In a collaborative research project between Drs. Salah Arafa and and Cynthia Nelson of the American University in Cairo and Dr. Edward Lumsdaine of the New Mexico State University, a study will be made of the social impact upon an Egyptian village of the introduction of solar technology. The village which has neither electricity nor an acceptable water supply, is already favorably disposed to the change. Both 'low' technologies, such as water heaters and ovens, and 'high' technology, such as electricity generation, will be selected and applied to food preparation, water purification, water pumping, and biomass conversion. The effectiveness of the new technologies in fulfilling the villagers' needs as well as fitting into their social structure will be evaluated. Attempts will be made to generalize the experience for application to similar rural communities.

The problem of the impact of technology on life style is prevalent at all socioeconomic levels in almost all countries of the world. Low-technology, isolated rural villages are particularly prone to social disruption as technology is introduced into the village life. This is true in Egypt, other LDC's, as well as in parts of Southwestern U.S.

This award supports the costs of the project at the New Mexico State University, while a companion award, INT78-01127, supports the costs at the American University in Cairo.

SUPPORTED BY U.S. National Science Foundation, Directorate for Scientific Technological & Internat. Affairs, Div. of International Programs

1.0162,

PERFORMANCE ANALYSIS OF A DOUBLE-POLYETHYLENE INFLATED HYBRID SOLAR SPACE HEATING SYSTEM

S.R. Kenin, Solar Room Co., *Taos, New Mexico* 87571 (EG-77-G-04-4129)

The purpose of this project is to determine the amount of solar heat that can be supplied by a double-glazed solar greenhouse collector for heating a single family dwelling. Other results will also indicate the actual cost effectiveness of such a solar collector. A test module consisting of 4 test cells has been constructed. Three of the cells have various configurations of solar greenhouse collectors and storage methods. The 4th cell is a control cell and has no provisions for solar collection or storage. Data is being gathered on the amount of electric back-up heat and amount of solar heat being supplied to each cell. The project is currently in the test phase, i.e., acquiring data during the heating season, and will move into the data analysis phase during the late spring. This project is subcontracted.

SUPPORTED BY U.S. Dept. of Energy

1.0163,

POTENTIAL EFFECTS OF SOLAR SYSTEM WORKING FLUIDS AS ECOSYSTEM CONTAMINANTS

D. Wilson, U.S. Dept. of Energy, Los Alamos Scientific Lab., *P.O. Box 1663, Los Alamos, New Mexico* 87544 (002684)

Solar heating and cooling of homes and commercial buildings is expected to be a rapidly growing energy industry which utilizes a wide range of chemical materials as working fluids for heat transfer and storage. This project in experimentation and evaluation addresses the understanding of the implications of accidental releases and disposal patterns which place these materials in the ecosystem. An emphasis is placed upon screening for those substances which may damage vegetation, disturb soil microflora, and affect plant litter reduction or release toxic substances to ground water. Experimental work involves development and application of test systems using hydrophonic and soil plant growth and reproduction tests, soil microflora respiration, and microcosms and field plots for evaluating effects of working fluids on the chemical composition of ground water. The application of these results will be made in developing guidelines for handling and disposal of environmentally acceptable solar system working fluids, including a capability to assess any significant pathways for toxic substances to man.

SUPPORTED BY U.S. Dept. of Energy, Office of Health & Environmental Research

1.0164,

SOLAR HEATING AND COOLING DEMONSTRATION POND PROJECT

Unknown, University of Albuquerque, Undergraduate School, *St. Josephs Pl. N.W., Albuquerque, New Mexico* 87105 (EG-77-F-03-1514)

SUPPORTED BY U.S. Dept. of Energy

1.0165,

SALT-GRADIENT SOLAR PONDS

H.C. Bryant, University of New Mexico, School of Arts & Sciences, Dept. of Physics & Astronomy, *University Hill N.E., Albuquerque, New Mexico* 87106 (EG-77-S-04-3977)

Our research is centered on a full-scale salt-gradient solar pond which has been in operation at UNM since 10/75. Our object is to obtain a thorough understanding of the physical behavior of the pond, and the development of a mathematical model adjusted to agree with extensive data taken on the actual pond. Although current research is primarily geared to space heating, industrial process heating as well as crop drying, water desalination, cooling and electricity production are possible applications. In August, 1977, the large storage layer of our pond reached a temperature of 93 degrees C (199 degrees F), which is a record high for sodium chloride ponds with storage. Heat, in the amount required by a 185 square m (2000 square feet) house in Albuquerque, has been successfully extracted from the 175 square m pond on a daily basis since November 4, 1977.

BIBLIOGRAPHIC REFERENCES: H.C. Bryant and Ian Colbeck, A Solar Pond for London, Solar Energy 19, 321 (1977); F. Zangrando and H.C. Bryant, Operation and Maintenance of a Salt-Gradient Solar Pond, Helioscience Institute Conference Proceedings, Palm Springs, CA, May 1-4, 1977

SUPPORTED BY U.S. Dept. of Energy

1.0166,

SOLAR SPACE HEATING AND HOT WATER DEMONSTRATION POND PROJECT

C. Grimm, (No Performing Organization Reported), *New York* (EG-77-A-02-4422)

SUPPORTED BY U.S. Dept. of Energy

1.0167,

HEATING OF GREENHOUSES AND RURAL RESIDENCES WITH SOLAR ENERGY

L.D. Albright, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (7005-20690-018-A)

OBJECTIVE: Develop and evaluate an active-passive hybrid solar heating system utilizing low-cost solar heat collection and retrieval and the concept of variable mass for solar heating of greenhouses.

APPROACH: Test and demonstrate a new low-cost concept for utilizing solar energy to heat greenhouses; match solar heating components into the 'Q-Sol' system to produce compatible night and day greehnouse conditions, with the 'night' greenhouse effectively shrunk to contain only the plants and a heat source by using a variable thermal mass and a hybrid active/static means of solar energy retrieval. Determine night temperature requirements of a variety of plants to find those suited to the characteristics of passive solar heating systems. Formulate a method to inter-relate capital costs, market factors, and plant factors as an analysis tool to predict cost effectiveness of patented greehouse solar heating systems.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0168,

SOLAR HEATING AND COOLING OF GREENHOUSES AND RURAL RESIDENCES

D.R. Price, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123326)

OBJECTIVE: This study is proposed to provide sound technical information to evaluate the overall merits of utilizing solar energy for heating and cooling of greenhouses and residences. The effort will be directed toward the application of present collector and storage technologies to greenhouses and residence systems. The general objective will be to analyze, design, and test the combination of solar collection devices and storage systems to utilize solar energy as effectively as possible to provide the greatest possible portion of the energy required.

APPROACH: An interdisciplinary team of engineers, architects and economists will carry out detailed engineering analyses, design of building forms, and economic analyses to satisfy the objectives of the project. An existing solar energy house will be instrumented to measure the effectiveness of solar energy use. Mathematical models of the greenhouse heat balance will be developed and used to simulate the application of solar energy to heating of greenhouses.

PROGRESS: Tests were completed to quantify the effects of using an active air collection system, with rock storage, to supplement the heating system of a double polyethylene, air-inflated greenhouse. From February through April of 1977, the solar system carried 25% of the total needs. The same data showed the greenhouse acts as a solar collector with an efficiency of 20-25%. A Lawand-style asymmetrical greenhouse was then constructed, with the same air-collection system, to determine the benefit of changing the greenhouse design to one which is more energy efficient. Tests in this house are continuing. Tests were initiated to determine the effects on plant growth of a variety of greenhouse insulation techniques. Insulating a glasshouse with a single layer of polyethylene, a double layer of polyethylene (air inflated) and aluminum foil covered rigid insulation are being evaluated. In addition, plant growth studies in the Lawand-style solar house were initiated. Results will be forthcoming.

SUPPORTED BY New York State Government

1.0169,
SOLAR DOMESTIC WATER HEATING IN RURAL/MIGRANT HOUSING

D.M. Stipanuk, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123341)

OBJECTIVE: Reduction of the cost of water heating for rural dwellings by the substitution of a renewable form of energy for currently used electric or LP fuels would aid the economic viability of rual people. The publication of actual experience with solar systems in NYS would greatly aid the people of NYS as they assess the viability of solar water heating for their homes. The training of installers for solar water heating systems will improve system reliability and reduce costs.

APPROACH: Seven to eight solar domestic water heating systems will be installed in migrant worker dwellings near Sodus, NY. Installations will be made by CETA workers following completion of a training course. Performance of these solar systems will be monitored and reported on a regular basis. Comparisons will be made to conventional (electric) water heating systems in similar dwellings.

SUPPORTED BY New York State Government

1.0170,
SOLAR HEAT PUMPS FOR HEATING AND COOLING OF BUILDINGS

Unknown, General Electric Co., Corporate Research & Development, *1 River Rd., Schenectady, New York* 12305 (ET-78-C-03-1719)

SUPPORTED BY U.S. Dept. of Energy

1.0171,
PORPHYRIN CHEMISTRY

J. Fajer, U.S. Dept. of Energy, Brookhaven National Lab., *Upton, New York* 11973

Synthetic, structural, theoretical and physical chemistry of porphyrins; electronic structure and chemical properties of porphyrins and their radicals; biological role of porphyrin ions in photosynthetic and metabolic reactions; applications of these catalytic reactions to energy conversion systems such as solar energy production of electricity by photo-excitation of porphyrins deposited on solid interfaces or isolated in micelles, the production of hydrogen and/or oxygen in solution using porphyrins to mimic the photosynthetic cell and photo-decompose water, and also to fix nitrogen photochemically via porphyrin derivatives. Techniques include optical absorption, electron spin resonance (esr), nuclear magnetic resonance (nmr) and electron nuclear double resonance (endor). Redox reactions induced chemically, photochemically and electrochemically. (DOE/ER-0002)

SUPPORTED BY U.S. Dept. of Energy, Office of Energy Research

1.0172,
PHOTOELECTRODIALYSIS, RESEARCH AND DEVELOPMENT

G. Hind, U.S. Dept. of Energy, Brookhaven National Lab., Dept. of Biology, *Upton, New York* 11973 (001827)

In chloroplasts in vivo a gradient in pH as great as 3.0 units can be developed across the thylakoid membranes in the light. By addition of exchange diffusion carriers, this could be converted to a salt gradient of 1000:1. A synthetic membrane embodying oriented photochemical reaction centers and exchange diffusion carriers is sought which will be large enough to install in solar ponds. The support phase under study is nylon and the photochemical centers are those from Halobacterium purple membrane, chloroplast photosystem 1, or bacterial photosynthetic particles. The exchange diffusion carrier will be a lipophilic ionophorous antibiotic initially. Solar panels containing flat membrane sheets on supports behind transparent windows, input and output plumbing. Facility for tandem operation. Throughput of saline for desalination to less than 500 ppm to be comparable to that of current electrodialysis installations (200,000 gal/day).(1) Synthetic membrane containing active photochemical reaction centers. (2) As (1), but membrane asymmetric and showing vectorial H/sup / pumping. (3) As (2), with exchange diffusion carriers, giving NaCl gradient ●10:1. (4) Demonstration model, 1 gal/h (from 5000 ppm NaCl to 500 ppm NaCl).

SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

1.0173,
SOLAR ENERGY APPLICATION AND ENERGY CONSERVATION FOR LOW INCOME RURAL FAMILIES

W.A. Streat, University of North Carolina, North Carolina Agricultural & Technical State University, School of Engineering, Dept. of Architectural Engineering, *N. Dudley St., Greensboro, North Carolina* 27411 (NC.X-PR-0001)

OBJECTIVE: Develop energy conserving designs of economically feasible systems to meet energy needs of housing for low income rural families.

APPROACH: Preliminary work will include making a survey of housing and energy needs of rural low income people of North Carolina and making a feasibility study of utilizing non-conventional energy sources in existing rural houses using solar energy. Price and performance data will be gathered on currently available solar hardware and computer codes will be written to perform systematic economic optimization studies. Cost effect system designs (one hydronic and one air) will be developed and made available to rural families.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Carolina

1.0174,
A BENEFIT-COST APPROACH TO POTENTIAL SOLAR ENERGY UTILIZATION IN RURAL RESIDENCES OF WESTERN N.C.

D.Y. Chen, University of North Carolina, North Carolina Agricultural & Technical State University, Agricultural Experiment Station, Dept. of Economics & Business, *N. Dudley St., Greensboro, North Carolina* 27411 (NC.X-013-5-79-531-5)

OBJECTIVE: Develop a conceptual framework for the quantification of the costs and benefits on potential solar energy utilization for space and water heating in rural western North Carolina residences; gather and analyze information and the responses in terms of the awareness and acceptances of potential solar energy utilization from selected rural residents; establish a set of tentative criteria on the potentiality of solar energy utilization in rural housing and provide feed-back to rural residents for actual application, to governmental agencies for policy considerations, and researchers for further studies.

APPROACH: This research will be conducted in a benefit-cost economic analytical framework using primary and published data including field survey in selected counties in western North Carolina. A research team includes the project director, a research associate, a research assistant, and others would need to be assembled for this task. Selected models of solar space heating and solar water heating based on the existing technology will be used as the foundation in seeking responses and establishing criteria for potential propagation.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Carolina

1.0175,
SOLAR ENERGY UTILIZATION IN TOBACCO BULK CURING/GREENHOUSE SYSTEM

B.K. Huang, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Biological & Agricultural Engineering, *Raleigh, North Carolina* 27600 (7095-20190-007-A(1))

OBJECTIVE: Provide for practical aspects of immediate and effective utilization of solar energy for tobacco curing and greenhouse crop production.

APPROACH: Based on previous research for this system, computer aided analyses, modeling and simulation will be used to evaluate and optimize the collector design, energy storage and automation of air flow during curing. These design changes will be made on the existing bulk curing/greenhouse structure. Tests will be conducted on tobacco curing and data necessary for performance and cost utilization and for further analysis and simulation will be collected using a microprocessor based data acquisition system. Tobacco seedling and other plant growth research will be conducted in a bulk curing/greenhouse structure. Continuous growth data will be taken to determine the optimum environment for multi-layer growth of tobacco seedlings. Other greenhouse crops will be grown and studied for maximum economical utilization of the structure as a greenhouse.

PROGRESS: Hydroponic plant production in the greenhouse/bulk curing system was successfully accomplished with tomatoes and cucumbers. A basket system, which utilizes nutrient pumping from one container to the other and then back to provide nutrient uptake and root aeration, was selected as the most practical and efficient system for this use. microprocessor was used in the tobacco solar curing studies. This microprocessor controlled air flow for solar energy collection, storage and consumption as determined by the tobacco curing requirements and the greenhouse solar barn system. Utilizing this system, the LP gas requirement was 9% less than last year.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0176,
SYSTEMS APPROACH TO TOBACCO MECHANIZATION

B.K. Huang, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Biological & Agricultural Engineering, *Raleigh, North Carolina* 27600 (NC02504)

OBJECTIVE: Characterize biological factors related to producing and processing tobacco; reduce labor and production costs; improve tobacco quality; develop technology for greater modification and control of tobacco properties; optimize use of solar energy in greenhouse bulk curing system; improve efficiency of tobacco marketing system.

APPROACH: Laboratory, field, greenhouse and computer modeling studies to: Determine optimal conditions for uniform seed germination and seedling growth; identify economic mechanized system for production of high quality transplants and for transplanting; further mechanize and reduce energy requirements for harvesting and curing; relate process variables of curing to leaf and smoke chemistry for improved quality; study solar energy utilization in a greenhouse bulk curing system; evaluate and compare alternative market systems; further evaluate and test the concept of close-grown tobacco; develop computer models to optimize production systems.

PROGRESS: Collected operational on-farm data on 13 harvesters. Developed harvester scheduling and selection models and computer program to schedule buyers on markets. Evaluated large bale marketing concept. Used hot water (potentially wood or coal heated) circulating through heat exchangers as sole heat source for bulk curing tobacco. Will test wood burning water heater in 1979. Used scanning electron microscopy to study seed germination physiology. Mechanized transplant production under perforated plastic showed improved seedling uniformity and growth. High density, direct seeding gave satisfactory plant stands and high yields. A new solar energy collection and heat recovery curing system gave significant fuel savings. Developed facility for modeling curing energy. Addition of wet-bulb controller and micro-computer to control solar energy collection, utilization and storage to greenhouse-bulk curing solar barn resulted in significant energy saving. Used structure as greenhouse for hydroponic tomato and tobacco transplant production. Evaluated effects of curing box height and air flow on curing costs. Built machine to prune lower leaves. Ethrel causes leaf drop and did not appreciably shorten curing cycle. Curing barn costs make it economical to increase barn use by extending harvest.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Carolina

1.0177,
LOW-GRADE THERMAL ENERGY STORAGE SYSTEMS FOR GREENHOUSES
D.H. Willits, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Biological & Agricultural Engineering, *Raleigh, North Carolina* 27600 (7010-20690-023-A)
OBJECTIVE: Develop and test low-temperature rock-bed storage systems that can be added to existing solar-heated greenhouses and determine specific engineering to facilitate the design and use of such systems in an economic manner.
APPROACH: Construct a laboratory-size rock storage bed and determine the fuctional relationship among pressure drop, air flow, rock size and shape, bed porosity, and bed height. Construct a full-scale rock bed based on these relationships next to a 6 m x 12 m fiberglass quonset greenhouse for storage of excess collected greenhouse energy and compare the energy economy and plant growth in this greenhouse with a similar greenhouse without rock storage.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0178,
ENGINEERING FOR FLORICULTURAL AND ORNAMENTAL CROP PRODUCTION
D.H. Willits, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Biological & Agricultural Engineering, *Raleigh, North Carolina* 27600 (NC03549)
OBJECTIVE: Reduce energy costs and improve environmental control in greenhouses; reduce labor/production costs of nursery and greenhouse operations.
APPROACH: Attempts to reduce energy costs will be made by incorporating rock bed storage systems into greenhouses. Reduction of nighttime heat losses and development of alternate energy sources will be investigated. Mathematical models will be developed to facilitate improved environmental control. Attempts to reduce labor/production costs in nursery and greenhouse operations will be made by using a systems approach. Totally integrated production models will be developed and used to evaluate production alternatives and optimize resource allocations.
PROGRESS: Part I: A full-size rock bed energy storage (1 m x 3 m 12 m) was added to a 7 m x 12 m fiberglass greenhouse to store the energy collected by the house during the day so that it can be used at night. The storage contained approximately 40 tonnes of 2 cm dia crushed granite and the air is circulated through the bed with a 56 cm dia blower. The north end of the greenhouse was insulated to an R-value of 15 to improve the collection efficiency of the house. A foil covering was placed inside the insulation to compensate for light loss. The energy savings provided by the system over an identically exposed fiberglass house was 17.5% for the months of Oct., Nov., and Dec. This figure has already been adjusted for increased electrical consumption due to the blower. An additional study of insulated north wall alone was conducted during the spring. Total energy savings amounted to 10.6% for the months of Feb., Mar., April, and May. This was higher than expected based upon area ratios alone. Evidence suggests that this may be related to increased solar collector efficiency rather than reduced infiltration as indicated in the literature. Part II: Developments in the systems analysis part of the project were limited to the collection of data from growers to be used in developing the general linear programming (LP) model. This work is being done in the Department of Horticultural Science under Project NCO 3606. A skeleton framework LP has been developed and tested against limited data.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Carolina

1.0179,
DEVELOPMENT OF INEXPENSIVE AQUACULTURE SYSTEMS FOR HOME (SUBSISTENCE-TYPE) CULTURE IN NORTH CAROLINA
W.W. Hassler, University of North Carolina, North Carolina State University, School of Agriculture & Life Sciences, Dept. of Zoology, *Raleigh, North Carolina* 27607 (NC05448)
OBJECTIVES: To develop inexpensive and efficient methods of fish culture for home consumption. To determine best species of fish and algae for home culture. To determine costs involved in home culture system.
APPROACH: Use translucent solar-algae tanks and use solar energy to grow algae which can be utilized by herbivorous fishes (tilapia). Determine methods of utilizing solar-algae tanks throughout year: outside with insulation; within greenhouse; outside with cold-tolerant species; outside with solar collectors. Determine production of different species in monoculture, polyculture, and diseasonal use.
SUPPORTED BY North Carolina State Government

1.0180,
SOLAR HEATING AND COOLING DEMONSTRATION PROJECT
Unknown, Jamestown College, Undergraduate School, *Jamestown, North Dakota* 58401 (EM-78-F-03-2150)
SUPPORTED BY U.S. Dept. of Energy

1.0181,
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
J. Lindley, North Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fargo, North Dakota* 58103 (ND01422)
OBJECTIVE: Conceptualize, develop, analyze and optimize animal manure management systems with least cost and energy requirements for pollution control compatible with changing socio-politico-economic patterns. Develop optimal animal manure management systems to meet the evolving environmental and economic requirements and be compatible with the increasing needs of our nation and the world for animal protein.
APPROACH: The adaptability of various manure management systems to conditions that exist in North Dakota will be evaluated. Housing for beef, dairy, poultry, and hogs will be included in the work. Both installation costs and operating costs will be considered in developing economic appraisals of systems. The energy required to install and operate equipment will be measured when new facilities are installed. The water vapor that is released in various handling systems will be determined. The quantity and quality of gases will also be measured. The odors generated and the effects of manure on runoff will be related to various systems of land spreading. The effectiveness of stabilization of manure by microorganisms will be measured along with the degree of control that can be achieved with pathogenic organisms. Insect control will be included in this phase of the work. Systems utilizing solar or wind energy for manure de-watering will be tested. Briquetting and other processes that may facilitate utilization of manure will also be included in the work.
PROGRESS: Lagood Effluent: The effect of spreading lagoon water on a shelterbelt has been under study since 1972 by Robert Heintz of the Horticulture Department. Soil samples have been taken to evaluate possible nutrient build-up in the soil profile. An economical distribution system was installed this summer. A single coil (7.6m) of corrugated plastic pipe with 1.25 cm diameter holes was placed in the middle of the shelterbelt. Hole spacing varied from .15m to .30m. Anaerobic Treatment of Swine Waste: Low temperature anaerobic treatment of swine waste is being studied by Dr. Paul Holmes of the Department of Bacteriology. The microflora of laboratory scale digesters started from hog waste lagoon samples and did not adapt efficiently to low temperatures when operated isothermally at 4 degrees C and 15 degrees for one year. Numbers of methanogens were estimated by dilution extinction (Text Truncated - Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Dakota

1.0182,
PLANTS IN PASSIVE SOLAR ENERGY SYSTEMS
R.E. Zuber, North Dakota State University, Agricultural Experiment Station, Dept. of Horticulture & Forestry, *Fargo, North Dakota* 58103 (ND02222)
OBJECTIVE: Evaluate radiation transmission of deciduous native and ornamental plant species for their potential usefulness with passive solar energy systems. Establish criterion by which plants may be compared and selected for use in passive solar energy systems.
APPROACH: Solar radiation transmitted through deciduous plants will be measured. Both native and ornamental trees, shrubs, lianas, and vines will be studied. Comparison between species will be made to determine which plants are best suited for use in passive solar energy systems.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Dakota

1.0183,
USING THE SUN AND WASTE WOOD TO HEAT A CENTRAL OHIO HOME
T. Kimpel, (No Performing Organization Reported), *Ohio*
SUPPORTED BY U.S. Dept. of Energy

1.0184,
PERFORMANCE OF PASSIVE SOLAR HEATED PATOKA NATURE CENTER
Unknown, Miami University, Graduate School, *Oxford, Ohio* 45056 (EG-77-G-04-4090)
SUPPORTED BY U.S. Dept. of Energy

1.0185,
SOLAR HEAT FOR GRAIN DRYING
H.M. Keener, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00232-SS)
OBJECTIVE: Determine effectiveness of solar collectors in heating air, effects of solar heated air (low temperature) compared to unheated air on the rate of drying soybeans and shelled corn, effect of weather variations on solar collectors, operational procedures for using bin dryers with solar collectors.
APPROACH: Conduct a field study on integrated solar heat collector - grain drying systems under field conditions. Study will use three bins, each 14 ft. dia. x 8 ft. high. Two bins have solar collector units (an inflated plastic cover over a 1000 ft black plastic obsorber) connected for the heated air studies, one using continuous air flow and one moving drying air only during daylight; while one bin will be using unheated air in continuous operation. Simulation of solar drying systems will be made.
PROGRESS: A black painted vertical panel with a double layer of plastic was tested for use as a low temperature solar collector on a farm structure. Collection efficiency was 30% at an air flow of 1.45 meter per minute (flow/collection area). A commercial plastic solar collector, SOLORON, was tested from 1974 to 1977. It's efficiency dropped from 40% to 32% in 18 months (life of collector) of use. A new plastic solar collector from Kuss Corporation, was used during 1978 tests and found to be about 45% efficient. 1974-78 low-temperature and natural air grain drying tests suggest that instantaneous solar energy utilization will economize electrical energy consumption during low-temperature drying, but cost can still exceed that of high temperature drying. Engineering and economic analysis of a high performance solar collector, SUNPAK, coupled with storage, indicated that this system for Fall grain drying would be about 18 times more expensive compared to using electricity (5 cent/kwh) and LP gas (45 cent/gal.). Based on 1975 Wooster, Ohio weather (year of lowest radiation level from May through September for years 1970-77), the simulation indicated that a water storage tank of 545,000 liters coupled to 238 sq. m. of SUNPAK would reach about 95 degree C temperature (with no heat loss considerations) and would suffice for drying 254 Kilo tonnes of corn from 25% (w.b.) with a 60% heat exchanger efficiency.
SUPPORTED BY Ohio State Government

1.0186,
CORN PRODUCTION METHODS TO ACHIEVE ENERGY CONSERVATION IN DRYING OHIO'S CORN CROP
H.M. Keener, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00273-SS)
OBJECTIVE: Achieve significant reduction in the fossil fuel energy required to dry corn in Ohio by the combined use of alternative energy sources and energy-effective management techniques. Compile research results on crop management associated with corn grain water content at harvest and energy efficiencies of various methods of drying the grain. Disseminate results to Ohio's farm families and agribusiness in any manner necessary to achieve significant adoption of improvements.
APPROACH: Research work on energy requirements of corn production systems has been conducted over the last four years at OARDC. This work has involved analyzing energy uses in crop production. Also, studies on 1) solar and natural air drying systems, and 2) effects of time of planting, variety selection, weed control, fertilizer levels and other cultural alternatives on crop moisture, have been accomplished. Now, the available information will be compiled into a bulletin describing all aspects of energy conservation in harvesting and drying corn. Data may be collected from field trials or demonstration plots to supplement existing data.
PROGRESS: Work was begun on thin-layer drying rates of shelled corn as affected by hybrid selection

and how these relate to grain dryer throughput and fuel consumption. Laboratory tests of thin-layer drying were conducted on four corn hybrids harvested from three Ohio locations. Drying constant results (based on initial drying to moisture ratio of 0.60) ranged from 0.236 to 0.409 per hour for drying temperature of 52 degrees C. Kernel size measurements were made for two moisture levels. Computer analyses of crossflow, deep-bed drying systems were made by using the log model to obtain drying times. Efficiency ratings and total energy costs have been evaluated for ranges in systems operating conditions. ASAE Paper #78-3521, Measuring Performance of Grain Drying Systems, was written and presented by H. M. Keener and T. L Glenn. It shows the effects of initial conditions and grain characteristics on performance of low and high temperature crossflow drying systems. Performance measurements for grain drying systems involving rates of moisture removal and energy usage were discussed. Definitions and standard performance test conditions were proposed. (Text Truncated -Exceeds Capacity)
SUPPORTED BY Ohio State Government

1.0187,
EXPERIMENTAL STUDIES ON A SOLAR POND FOR HEATING AND COOLING GREENHOUSES AND RESIDENCES
T.H. Short, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (7008-20690-021-A)
OBJECTIVE: Demonstrate a working solar pond and heat extraction system for heating an adjacent greenhouse and evaluate the economic feasibility and efficiency of a solar pond as an integrated solar collector and heat storage unit for greenhouses and homes.
APPROACH: A salt pond (28x60x12 ft deep) will be monitored for daily temperature and salt concentration gradient. Radiation profiles above and within the pond will be studied under different weather conditions and seasons. The efficiency of a heat extraction system will be measured and the salt pond will be evaluated as a solar energy collection and storage system for providing solar heat for greenhouses or residences. Emphasis will be given to developing design criteria for optimum pond depth, required insulation in sides and bottom, required size of gradient zone, and required maximum salt concentration for stability and maintenance. A computer model will be developed to simulate the solar pond heating system and an energy accounting system will be developed to evaluate the various energy pathways in the experimental system.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0188,
RESEARCH ON SOLAR PONDS FOR HEATING AND COOLING GREENHOUSES AND RURAL RESIDENCES
T.H. Short, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00238-SS)
OBJECTIVE: Lower fossil fuel heat requirements for greenhouses and residences by studying a 'bubble' covered solar salt pond (sized for a single family 2000 ft residence) as an integrated solar collector, heat storage unit, and heat source for a greenhouse.
APPROACH: A salt concentration gradient will be established to keep the pond non-convective to attain 90 C temperatures. A plastic greenhouse will cover the pond for heat retention and weather protection. Heat will be extracted by a fresh water heat exchanger. The fresh water will either be used directly in the greenhouse or warmed by a heat pump. The heat pump will also be evaluated for moving heat from the greenhouse to the pond. An energy accounting and budgeting system will be developed for correct source, flow and sink for heat at various times.
PROGRESS: An experimental solar pond (8.5 x 18.3 x 3 m deep) is designed to demonstrate the heating of an adjacent greenhouse. A controlled salt concentration gradient in the upper half prevents convection and is a transparent insulator while the bottom is convective. During 1978, the average daily pond temperature increased 0.33 degrees C/day from March 21 (16.8) until July 21 (56 degrees C). The temperature rose 0.8 degrees C/day during 4 clear days. A goal of 80 degrees C may have been reached except that convection in the lower half of the pond eroded the insulating gradient resulting in a 55 degree C equilibrium temperature during the latter part of the summer. Salt was added along the base of the north wall to halt gradient erosion, but the whole stability problem needs further evaluation. A heat extraction system was installed with a shell and tube heat exchanger for transferring heat from the brine to water. When the pond is above 40 degree C, water is circulated through a coil in a greenhouse air handler. When the pond temperature is below 40 degree C, the warmed water is piped to a heat pump. The heating system was operated successfully without disturbing the gradient. Numerous startup problems were associated with regulating water flows to match the capacity of the 7.5 KW heat pump. The results to date indicate the heating system as designed will work, but not enough data were obtained to establish operational efficiencies and design guidelines.
SUPPORTED BY Ohio State Government

1.0189,
MECHANIZATION OF GREENHOUSE CULTURAL AND ENVIRONMENTAL SYSTEMS
T.H. Short, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00576)
OBJECTIVE: Establish new technology to reduce labor cost, labor drudgery, and fossil fuel heating requirements for greenhouses.
APPROACH: Labor-aid mechanisms will be developed to reduce drudgery and increase labor efficiency of growing greenhouse crops under present cultural systems. Machinery will be developed for high population cultural systems to achieve high production of tomatoes, lettuce and other greenhouse crops. Mechanical methods of adding nighttime insulation to greenhouse covers will be developed and tested. Mechanical systems for transferring heat to a greenhouse from solar collectors and heat storages such as a solar pond will be studied and developed. Greenhouse energy sources will be integrated into workable, efficient and economic systems of crop production.
PROGRESS: Major emphasis has been to develop a mechanized polystyrene bead insulation technique to reduce greenhouse night energy requirements by 80-90%. Five inches of beads are pumped between double plastic walls at sundown and removed at sunrise for an insulation R = 20 (normal R = 1.4). Beads (3 - 6 mm. dia.) are pumped through blowers with air. This mechanical handling causes no apparent deterioration of the 16 kg/mue3 material. An air/bead ratio of 25:1 results in near optimum pump capacity. The 25:1 ratio is typical during filling but 50:1 usually occurs while evacuating the greenhouse covers. On an experimental 6m x 12m greenhouse, a 0.75 Kw blower rated at 28 CMM (3450 RPM, 25 mm static water pressure (s.p.)) will pump about 1.3 cu. m of beads per minute and fill the house in 12 min. The mixture is pumped at less than 25 mm. s.p. to prevent plastic rupture. Air is continuously evacuated from between the plastic sheets with a similar-sized blower to prevent rupture and control the thickness of fill. Static cling of the beads is controlled by 135 ml of glycerine added to each cubic meter of beads. Other antistatic chemicals are also effective. Moisture between the plastic is a problem during sub-freezing weather. Beads can freeze on the inside surface of the outside cover and cause shading. All air inlets to blowers should be outside the humid greenhouse, and the bead storage should be dried with one of the blowers on dry days. Many refinements are still required before commercial application.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Ohio

1.0190,
SWINE ENVIRONMENTAL SYSTEMS TO OPTIMIZE FEED AND FUEL UTILIZATION
D.P. Stombaugh, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO000620)
OBJECTIVE: Develop improved environmental modification techniques which reduce energy consumption and develop a simulated model describing nutritional-environmental interactions in swine to evaluate these environmental modification techniques.
APPROACH: This dynamic model will provide rate of gain, body composition, and feed efficiency responses to changes in feed energy intake, diet composition, frequency of feeding and the thermal environment. Model development will utilize data in the literature and data from laboratory studies in an environmentally controlled calorimeter. The proposed environmental modification techniques will be designed and evaluated theoretically using prototype models and then installed on the farms of commercial operators to evaluate economic and technical feasibility.
PROGRESS: A dynamic simulation model has been developed which describes feed intake; digestion and absorption; the chemical-biological pathways for carbohydrates, fats and proteins; protein and fat synthesis and degradation; whole body energy balance and thermoregulation. Model parameters have been evaluated by comparing model predictions with experimental and theoretical work. The model simulates growth and energetic efficiency in pigs between 5 and 25 weeks of age in more detail than previous models. To validate the model, comparisons will be made with results to be obtained from a recently completed animal calorimeter. This calorimeter houses a group of pigs (up to four) and permits the continuous determination of sensible and latent heat losses, oxygen consumption, and feces and urine collection. Preliminary calorimeter calibrations and trial runs have been completed and experimental trials are being initiated. Initially, the experimental trials will include the evaluation of protein level (12 and 18%), temperature (15 degrees and 30 degrees C) and step changes in temperature on the performance of six- to ten-week-old pigs. A new environmental control system for warm confinement animal housing using subsurface energy extraction and dispersal has also been designed for farrowing and nursery buildings. Additional funding is being sought to test this system and various solar energy systems for swine housing.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Ohio

1.0191,
MICROPROCESSOR CONTROL OF A GROUND WATER HEAT PUMP
Unknown, Telesis Lab., *41 S. Paint St., P.O. Box 387, Chillicothe, Ohio* 45601
SUPPORTED BY U.S. Dept. of Energy

1.0192,
SMALL DISPERSED SOLAR SYSTEM APPLICATIONS
Unknown, U.S. National Aeronautics & Space Admin., Office of Aeronautics & Space Technology, Lewis Research Center, *21000 Brookpark Rd., Cleveland, Ohio* 44135 (776-91-02)
The objective of this RTOP is to define small solar power system applications for remote or isolated communities, in the U.S. and in developing countries, which can utilize solar photovoltaic and wind energy power technology to meet specific community needs. Two tasks will be utilized to carry out this objective. First a study will be implemented, in conjunction with DOE and USAID as appropriate, to define applications in remote communities of the U.S., and selected developing countries, which could be served by photovoltaic and/or wind energy systems. Domestic applications will include those judged responsive to the anticipated needs of DOE's domestic solar programs. Foreign applications will include those responsive to USAID's programs for human need as well as DOE's international efforts. To complement the study, second task conducted in-house, will investigate and experimentally verify a limited number of candidate energy systems and typical load devices suitable for remote community applications.
SUPPORTED BY U.S. National Aeronautics & Space Admin., Office of Aeronautics & Space Technology, Lewis Research Center

1.0193,
UNCONVENTIONAL ENERGY SYSTEMS
H.J. Allison, Oklahoma State University, Agricultural Experiment Station, Dept. of Electrical Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075
The project objective is to develop an energy system which operates from solar, wind, and biomass resources in such a manner that it provides reliable energy to a typical village in a remote area of one of the developing countries.
SUPPORTED BY Oklahoma State Government

1.0194,
DRYING FOOD MATERIALS BY DIRECT APPLICATION OF SOLAR ENERGY
G.H. Brusewitz, Oklahoma State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL01652)
OBJECTIVE: Demonstrate the use of a directly heated, enclosed solar dryer for drying food materials during processing. The objectives for the first year are to: Design, construct and test laboratory-size, direct-heated, enclosed solar dryers to dry high moisture food materials. Determine the drying char-

acteristics of the material (initially this would be paunch) as a function of time, temperature, operating procedures, and paunch constituents. Investigate the handling aspects of the material in order to determine the need for a mechanical stirring mechanism and/or perforated bottom to insure maximum drying. Determine the conditions, both optimum and limiting, under which the dryer will operate in an environmentally acceptable procedure.

APPROACH: A direct heated, enclosed solar dryer will be designed based on the information in the literature. Beef paunch, a waste product in the past, will be used as an example of a high-moisture, low-value food processing plant material. The drying rate of this paunch material will be measured to predict the operation of a pilot-size solar dryer in future years. Operating procedure variables expected to have major influence are material depth, frequency of paunch filling and dried material removal, and initial and final moisture content.

PROGRESS: A prototpye direct solar dryer to dehydrate cow paunch contents was designed, built and tested. During good insolation, the dryer operated as a modified solar still with the vaporized moisture condensing on the under side of a fiberglass cover. During periods of low insolation, drying was done by a solid desiccant, silica gel. The desiccant was later regenerated by solar heated air from a concentrating collector. Of four tests in November, paunch moisture was reduced from 80 to 30% in five days. With average or above insolation no supplemental desiccant drying was needed. When insolation was 1/3 of average, desiccant usage during 4 of 5 nights supplied 76% of the moisture removal. A tunnel dryer was constructed to measure the drying rate of paunch as a function of relative humidity, depth, and age. The drying rate was highest for a thin layer and low humidity air. Drying was affected most by age at high humidities and least by depth. Air pressure was applied to paunch contained in a 60 liter drum having a screen bottom. (Text Truncated - Exceeds Capacity)

SUPPORTED BY Oklahoma State Government

1.0195,

DRYING AND CURING AGRICULTURAL PRODUCTS USING SOLAR ENERGY

B.L. Clary, Oklahoma State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL01601)

OBJECTIVE: Develop and evaluate practical systems for drying and curing peanut pods using solar energy. Specific objectives are: Design and test solar collector. Determine curing conditions for optimum utilization of solar energy, and develop energy storage systems.

APPROACH: The first year of the study proposes design, construction and testing of a solar collector to heat ambient air for direct use in drying peanut pods. Optimum operating conditions will be determined for optimum kernel quality and use of solar energy. Effects of cycling drying air temperature on a diurnal basis as well as reducing maximum drying temperatures as pod moisture content decreases will be studied. Systems and control mechanisms for varying air flow rate through the collector and drying bed as incoming solar radiation changes will be developed. Methods for storing solar energy during periods when incoming energy is not available will be evaluated and developed.

PROGRESS: An 11,000 ft 2 pond was covered with six mil polyethylene and supported using air pressures varying between 0.1 and 0.2 inches of water. The pond surface was covered with a layer of black polyethylene to act as an absorber of solar energy. Average temperature of the water continually increased until average pond temperature reached approximately 75 degrees F on November 6, 1978. Temperatures measured near the surface of water were as high as 95 degrees F. High temperatures were observed during periods of high solar insolation and decreased during nighttime periods when the pond was losing energy by radiation to the atmosphere. However, water temperatures measured at depths one foot below the water surface were stable and showed a continual increase in temperature throughout the test. On November 6, 1978, a cold front passed the site of the experiment and wind velocities increased to 20 m.p.h. At this time one sheet of the polyethylene cover ruptured due to fatigue at one of the folds placed in the plastic during shipping. Because of this failure in the structure the tests were terminated for the 1978 harvest season. In addition to the above test model study of the fresh water storage system was conducted to determine the efficiency of collection and storage of solar energy in a fresh water pond.

SUPPORTED BY Oklahoma State Government

1.0196,

FACTORS AFFECTING ORNAMENTAL PLANT PRODUCTION

C.E. Whitcomb, Oklahoma State University, Agricultural Experiment Station, Dept. of Horticulture, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL01548)

OBJECTIVE: Determine the effects of slow release fertilizer in the rooting medium on rooting and subsequent growth of cuttings. Develop slow release fertilizer system for nursery stock. Evaluate currently available herbicides for weed control in nursery stock. Study the effects of container size and plant growth on plant performance in the nursery and in the landscape. Determine the optimum shade, fertilizer level combination for production of shade requiring landscape shrubs.

APPROACH: Studies will be conducted at the OSU nursery which is maintained similarly to a commercial nursery. All studies will begin near the frost-free date for this area and allowed to grow for at least one full growing season and evaluated for marketability. In evaluating slow release fertilizers and container size, a portion of the plants will be planted in the field and maintained as in a landscape following the production phase. It is theorized that these conditions during production will have a dramatic effect on the plant in the landscape.

PROGRESS: A solar heated greenhouse 26' X 72' was designed and constructed. Energy is collected in the double poly covering using mist lines and stored in a sand bed beneath the floor. Early results suggest it can reduce the fossil fuel required by 60 to 80%. A series of studies were conducted to determine if any herbicides can be used safely to control weeds on a greenhouse floor. Hyvar X (bromacil) appears safe at rates of 15 or 30 lbs. aia. However, Pramitol 5 PS pellets and Pramitol (prometone) spray were devastating at rates as low as 10 lbs. aia. One half pint milk cartons were used as bottomless containers on raised wire bench out of doors. Quercus shumardi, Betula nigra, Pinus thunbergi, and Carya illinoensis were planted April 13 and grown with 0, 1000, 2000 or 3000 lbs. of N/A/yr. from 18-6-12 Osmocote. All seed germinated and responded quickly to the fertilizer in the growing medium. After 6 months pine were 10 to 12' tall and oaks were about 4'. Transplanting from the milk cartons to containers or the field was done in 102 F weather with no leaf drop, wilting or losses. Eleven shrub species were grown in shade of 0, 25, 30, 47, 63 and 73% and 3 fertility levels. Most species grew best in the 47 or 63% shade. (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Oklahoma

1.0197,

SOLAR HEATING AND ENERGY CONSERVATION FOR GREENHOUSES

C.E. Whitcomb, Oklahoma State University, Agricultural Experiment Station, Dept. of Horticulture, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075 (OKL01690)

OBJECTIVE: Develop and field test economical solar heated greenhouses containing their own heat storage system until the basic design criteria are stabilized. Experiment with pot and air temperatures until the minimum allowable soil and air temperature combinations are determined for the major horticultural crops. Develop a heat conversion system for nighttime operation until a heat loss reduction of 7 is routinely achieved. Develop the controls, sensors and actuators needed to secure optimum efficiency from the solar heating and storage system.

APPROACH: An improved greenhouse incorporating the lessons from the initial greenhouse will be built and instrumented. The original greenhouse will be converted to a gas heated greenhouse and used for comparison purposes. Grow an assortment of cultivars of the major greenhouse crops (Chrysanthemums, Poinsettias, tomatoes, and others) with known greenhouse temperature requirements in both the solar and gas heated greenhouses. A programmable controller will be installed in the improved greenhouse. The controller allows flexible rearrangement of the connections between inputs (thermostats, pressure sensors) etc.

PROGRESS: A solar greenhouse was consturcted during August, 1976, which captured the heat accumulated between 2 air inflated layers of clear polyethylene. The heat was stored in a sand-water layer beneath the floor. In 1978, the collection system was abandoned in favor of an inexpensive flat plate type collector constructed from galvinized corrugated steel. The water-sand heat storage beneath the floor was retained. The bottom heat provided plants growing on the floor appears to be more efficient than air heating systems although differences among cultivars of poinsettia and chrysanthemum were noted. Poinsettia cultivars Annette Hegg, Lady, Wonder Star and V-10 grew well with bottom heat to the containers but cool air temperatures while Top Star, C-1 and Jingle Bells were less suited to the cooler air temperatures. Chrysanthemum cultivars Winter Carnival, Altis, Puritan, Copper Anne, Bright Golden Ann, Spinwhell, Garland, Copper Bowl, Yellow Mandalay, Mountain Snow and Gold Star performed well whereas Intrepid Good, Velvet Ridge, Senorita, Gem, Pink Glo, Yellow Paragon, Royal Purple and Wild Honey were less satisfactory in the solar house. (Text Truncated -Exceeds Capacity)

SUPPORTED BY Oklahoma State Government

1.0198,

AGRICULTURAL STRUCTURES DESIGN UTILIZING ALTERNATE ENERGY SYSTEMS, MATERIALS AND CONCEPTS

M.L. Hellickson, Oregon State Higher Education System, Oregon State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *126 Agriculture Hall, Corvallis, Oregon* 97331 (ORE00360)

OBJECTIVE: Design & develop structures for lambing in high winter rainfall climates. Design, construct & test a simple solar powered apparatus that will develop shaft power. Compare overall heat transfer characteristics of typical greenhouse glazing materials. Design, construct & test low cost apparatus to provide freeze protection for nursery tree seedlings. Investigate utilization of non-fossil energy in livestock & plant production systems.

APPROACH: Investigate structural modifications that will improve conditions for lambing ewes & newborn lambs reared in high winter rainfall climates. Construct a solar powered apparatus that will produce shaft power by heating bimetallic coils. Test various greenhouse glazing materials to compare overall heat transfer characteristics. Construct & field test low cost radiant heaters designed to provide freeze protection for nursery tree seedlings. Investigate & assess various alternate energy sources & energy conservation schees that have potential for reducing energy consumption, &/or replacement of conventional energy sources.

PROGRESS: Progress has been made on the solar powered apparatus designed to provide shaft power. Several modifications of mechanical configuration and the incorporation of two plastic linear fresnel lenses has provided periodic rotation of the mechanism. Current modifications including addition of a fly wheel and multiple energy conversion devices are nearly completed. Additional testing of the basic concept with modifications is required. Comparison of the overall heat transfer characteristics of various greenhouse glazing materials including flat and corrugated fiberglass and a single layer of polyethylene has been completed. Results of this study indicated that energy savings expected by flat fiberglass over corrugated fiberglass would be equal to the difference in exposed surface area rather than projected surface area. Development and installation of freeze protection of nursery tree seedlings continues. Installation of approximately 9.3 m 2 of flat plate solar collectors and a water cooled condenser has been completed at the OSU Dairy Center. The system has been in operation approximately 3 months. Data are being accumulated to provide projections of systems performance and economics.

SUPPORTED BY Oregon State Government

1.0199,

ENERGY CONSERVATION SYSTEMS FOR GREENHOUSES

R.A. Aldrich, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *201 Shields Bldg., University Park, Pennsylvania* 16802 (PEN02194)

OBJECTIVE: Design, build and evaluate thermal insulation systems for use in greenhouses. Design, build and evaluate a greenhouse structure and environmental control system for efficient use of solar energy. Design, build and evaluate solar energy storage and recovery systems for use in greenhouses.

APPROACH: Materials with potential for reducing heat loss from greehnouses during dark periods will be evaluated by sample testing and analysis. Structural panels with high thermal resistance (R●10) will

be fabricated and tested to determine their mechanical and heat transfer properties. Structural systems will be designed that will satisfy solar energy transmission requirements during light periods and heat conservation practice during dark periods. The structural and environmental systems will be evaluated as greenhouses based on their potential for conserving thermal energy, for using solar energy for heating, and for crop production. Solar energy storage and recovery systems will be designed, built and tested to determine their potential for conserving fuel and providing for environmental control in greenhouses.
PROGRESS: The work has demonstrated clearly the value of moveable thermal insulation blankets in reducing heat loss from greenhouses and in reducing heating costs. Available commercial drapery hardware can be used to handle insulating blankets that can be folded for storage. Depending on greenhouse condition and type of thermal blanket used, annual space heating fuel requirements can be reduced from 20 to 50 percent with similar reductions in heating costs. Data on collection, storage, and use of excess internal solar heat showed it to contribute less than 10 percent of annual required space heat. Excess internal heat was available only during Spring and Fall heating periods. Flat plate solar collectors can reduce the use of fossil fuels for space heating requirements but may not reduce annual heating costs. A phase change salt shows some advantages in heat storage at temperatures under 34nC. Collection can begin and proceed at lower plate temperatures thus improving collection efficiency. Crop response studies show that it may be possible to grow several vegetable crops of disparate temperature requirements and crop cycles in the same greenhouse when cultivars are selected carefully and crops are scheduled to utilize natural trends in temperature and light availability.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Pennsylvania

1.0200,
SHEEP PRODUCTION SYSTEMS FOR SMALL FARMS
H.W. Harpster, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Watershed Research, *201 Shields Bldg., University Park, Pennsylvania* 16802 (1302-20100-016-A)
OBJECTIVE: Develop improved, low-cost sheep feeding, housing, fencing, and management systems with minimal energy requirements, and test their applicability and usefulness in small-farm and marginal-land production programs.
APPROACH: Forage and sheep production studies will be undertaken with a view toward development of low-cost systems of production which result in viable altlernatives for small-farm operators. Maximum use will be made of grazing, with legumes being relied upon to furnish nitrogen to the exosystem to the maximum feasible extent. Types and designs of internal fencing will be compared to ascertain minimal requirements. Non-conventional shelters will be tested, and water-supply units, utilizing solar panels and/or wind, will be designed and tested.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, North Atlantic Area

1.0201,
HEATING COMMERCIAL GREENHOUSES WITH SOLAR ENERGY
J.W. White, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Dept. of Horticulture, *201 Shields Bldg., University Park, Pennsylvania* 16802 (7004-20690-017-A)
OBJECTIVE: Design, test, and evaluate greenhouse structures, various greenhouse solar heating systems, and environmental control systems for efficiency of use of solar energy for greenhouse heating and plant growth.
APPROACH: Construct a seventh greenhouse of two-barrel vault design with a double-layer air inflated polyethylene cover, using one greenhouse as a control with a standard fossil-fuel heating system, compare various active and passive solar heating systems in the other six. Vary the solar systems so as to compare solar collection external and internal to the greenhouse, use of solar heated water or solar heated air, and rock and water heat storage systems. Install thermal blankets either thin (L 6 mil) or thick (G 6 mil), and compare their effectiveness. Monitor energy use and environmental parameters and correlate with system designs and evaluate plant response to the environments produced by each solar heating system.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0202,
ENERGY USE IN MARKETING AND PROCESSING FOOD AND FIBER COMMODITIES
W. Henson, Pennsylvania State University, University Park Campus, U.S. Dept. of Agriculture Commodity Economics Div., Poultry Products Program Area, *201 Shields Bldg., University Park, Pennsylvania* 16802 (CE-08-077-42-01)
OBJECTIVE: Develop estimates of energy required in marketing food and fiber commodities, present and future. Conceptualize and develop analytical models for aggregating and disaggregating energy data and studying alternatives relating to energy forms, locational, geographical and seasonal problems, commodity shifts, and long-range programs. Analyze potential energy use with alternative marketing methods, new technology, and conservation practices. Determine effects of modification of regulations on energy use by agricultural marketing firms and of national and international energy policies on costs, prices, location of production and marketing functions, and commodity mix. Suggest policy alternatives which would maintain a viable agriculture.
APPROACH: Develop estimates of energy use in the marketing of selected food and fiber commodities. Conceptualize and test an accounting model for measuring energy use in agricultural marketing and evaluate potential energy requirements with alternative marketing systems. Estimate State energy requirements for marketing by type of energy, season, commodity and function. Study effects of modified transportation and environmental regulations. Develop structural profiles of agricultural marketing firms with inputs and cost measurements.
PROGRESS: Available energy data and studies were reviewed. Schedules and plans for survey of energy use, conservation, and practices in marketing all food and fiber commodities were completed and analysis was begun. A framework for marketing energy data base was developed. A report on energy use and costs in Southern broiler processing plants was published. Data on energy use and costs in rendering poultry products was analyzed and a report was published on solar grain drying systems.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Commodity Economics Div.

1.0203,
UTILIZATION ECONOMICS AT THE REGIONAL RESEARCH LABORATORIES
M.E. Miller, U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div., *600 E. Mermaid Ln., Philadelphia, Pennsylvania* 19118 (NEA-12-107-42-04)
OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for products of the different regions and their comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra and interregional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.
APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.
PROGRESS: Economic advisory and research services were provided administrators and scientists at the regional research laboratories on the feasibility and consequences of various new technological developments. Contributions of economic services were to (a) an AID sponsored study of market potential of composite flour technology in developing countries, (b) a cooperative study between SEA/AR and Oklahoma State University on model tannery operations, (c) a cooperative study involving SEA/AR, FAS and the National Renderers Association on foreign market potential of tallow-based soap detergents, (d) a cooperative SEA/AR and ESCS assessment of potentials for additional use of crop residues in cattle rations, and (f) an assessment of feasibility and impacts of solar energy uses in agriculture. The latter three studies are continuing under work unit/Project No. NEA-12-107-11-00. Initial results indicated high fractose corn sweetener was not a perfect substitute for other sweeteners used in manufactured products. An update of the analysis contained in a 1975 report on PRO-XAN indicated commercial feasibility was greatly enhanced by new processing technology. An update of 1975 estimates of cost of producing Kenaf verified its continuing potential as a resource for manufacturing paper.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div.

1.0204,
QUALITY HOUSING ENVIRONMENT FOR LOW-INCOME FAMILIES
W.H. Allen, Clemson University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Long Hall, Clemson, South Carolina* 29631 (SC00091)
OBJECTIVE: Identify housing needs and satisfactions of low-income families and examine limitations to the attainment of quality housing. Formulate and evaluate innovative delivery systems in production, marketing, and financing in order to improve housing conditions. Formulate and evaluate innovative techniques and delivery systems for the transferral of housing information.
APPROACH: Community provisions and limitations to the attainment of quality housing will be investigated. Findings will be shared with architects, economists, environmentalists, planners, and engineers and with extension workers. Identification of the decision-makers in the provision and acceptance of low-cost housing innovations, including low-income families. Determine the kinds of housing information needed by low-income families. Transfer information to decision-makers in the housing industry at various levels including low-income families. Evaluate existing constraints to change and/or improve delivery systems for providing the housing product to low-income families.
PROGRESS: A panelized, free-standing solar powered domestic water heater was tested under actual domestic use conditions and the performance evaluated for a period of time under 'summer' conditions. Operating costs were almost negligible although significant fixed costs combined to produce a total cost per gallon in excess of estimated costs for a conventional electric water heating system. A computer simulation model was developed to predict the performance of the solar water heater prototype. Interrelationships between efficiency, capacity, consumption rates and water consumption patterns were developed by the model.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, South Carolina

1.0205,
SOLAR ENERGY FOR HOME HEATING
W.H. Allen, Clemson University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Long Hall, Clemson, South Carolina* 29631 (SC00307)
OBJECTIVE: Determine the daily energy requirements of two solar heated structures; the effectiveness of the solar energy collectors; the adequacy of the architectural design and solar heating systems in achieving a favorable living environment; the productive potential of the solar-heated greenhouse for supplying all or part of the food supply of the structure's occupants; the cost and energy savings (including costs of construction, heating and cooling, maintenance and food), if any, resulting from the designs used in the structures.
APPROACH: Two solar heated houses, one earth insulated and the other with an attached greenhouse, will be constructed. A study will be made of the design, construction methods, and energy efficiency of the structures. Instrumentation will be installed to monitor heat loss and other environmental factors prior to occupancy. Studies will continue during occupancy.
PROGRESS: a solar greenhouse residence (GHR) and a solar earth insulated home (EIH) were constructed on the Clemson University campus and occupied in December, 1978. Instrumentation was completed and data collection initiated in the GHR in December, 1978. Instrumentation is not expected to be complete in the EIH until February, 1979, although some data collection started in December. The greenhouse portion of the GHR was stocked with plants in October, 1978 and is proceeding very successfully. Two 'open house' events were very successful. Questionnaires regarding public reactions to the homes were completed by several hundred visitors and collected for analysis by an interdisciplinary team of scientists.
SUPPORTED BY South Carolina State Government

1.0206,
HOUSING FOR LOW--AND MODERATE--INCOME FAMILIES
W.H. Allen, Clemson University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Long Hall, Clemson, South Carolina* 29631 (SC00366)
OBJECTIVE: Provide innovative designs and research assistance for the construction of prototype housing systems and subsystems and for rehabilitation of existing housing and review and evaluate them by interdisciplinary teams.
APPROACH: Energy efficiency, consumer acceptance, overall system performance and system component performance will be determined for each of two solar prototype homes located on the Clemson University campus. One is an earth insulated home while the other is a 'greenhouse' home. Clemson University (SCAES) and RHRU-SEA-USDA are cooperating in the research activities.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, South Carolina

1.0207,
SOLAR ENERGY AND WASTE HEAT UTILIZATION WITH GREENHOUSE/RESIDENCE COMBO
D.O. Ezell, Clemson University, Agricultural Experiment Station, Dept. of Horticulture, *Long Hall, Clemson, South Carolina* 29631 (7007-20690-202-A)
OBJECTIVE: Develop, test, and evaluate designs for greenhouse-residence combinations that will conserve energy and optimize use of solar energy for supplemental heating of both structures, and provide space for production of family vegetable needs.
APPROACH: Complete construction of two additional prototype residences with attached greenhouses. Instrument, test, and evaluate these prototypes and continue tests of first prototype to determine the value of attached greenhouses in modifying the heating and cooling needs of associated residences and in supplying family food needs. Develop optimum vegetable production program for the greenhouses. Refine, modify, and improve plans for greenhouse-residence combinations based on construction feedback and costs, operation of mechanical systems, and on greenhouse food production data.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0208,
BUILDING AND UTILITY SYSTEMS TO REDUCE COSTS OF HOUSING FOR LOW-INCOME RURAL FAMILIES
H.F. Zornig, Clemson University, U.S. Dept. of Agriculture Agricultural Research, Rural Housing Res, *Long Hall, Clemson, South Carolina* 29631 (7729-20690-001)
OBJECTIVE: Reduce costs of components of building systems, including construction methods and materials, utilities and waste handling to lower initial and operational costs of housing for low-income rural families while improving livability and acceptability.
APPROACH: Develop innovative structural systems, construction techniques, and utilities, including heating, cooling, plumbing and electrical systems, that have potential for reducing initial or operational costs of housing structures, Test and evaluate these in laboratory and in prototype structures (in cooperation with other housing agencies). Investigations will include panelized construction techniques, new building materials, optimum mixes and combinations for building blocks and wall panels utilizing inexpensive or waste materials, heating and cooling with various forms of energy including solar energy, simplification of plumbing systems and improvement of waste control systems.
PROGRESS: A small (98 m) solar-heated house with earth embankment on three sides, was designed as a low-cost, energy-conserving home. It was constructed and is currently under test. Low-cost features include a previously developed panelized wood foundation system. Energy saving features include minimum windows, solar heated space and hot water, earth insulation, and a system to scavange excess house heat and supply it to a rock storage area adjacent to three walls. Improvements for the solar heated attic concept for home heating were designed into a second prototype unit for testing and plans for this were published. One greenhouse-residence concept for conserving energy and providing food growing space was constructed and is under test. Two additional units of improved designs are under contruction for testing. Two retrofits were designed to be added to typical small rural homes. The retrofitting included weatherizing techniques and add-on solar heating for space and hot water. These systems are being tested. Four types of low-cost solar heaters for domestic hot water were designed and are under test.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0209,
SOLAR ENERGY SYSTEM TO HEAT AIR FOR SWINE SHELTERS AND GRAIN DRIERS
M.A. Hellickson, South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Economics, *Brookings, South Dakota* 57006 (7003-20400-015A)
OBJECTIVE: Develop design criteria for a multi-purpose, diurnally-tracking solar intensifier to improve the energy collector system for swine shelter heating and corn drying.
APPROACH: Design and build a solar energy system, consisting of two-sided collector, a diurnally tracking, seasonally adjusted curved reflector and a native stone heat sink. Test system on swine shelters and on corn drying. Obtain system performance under local conditions and determine economic feasibility for simple and multiple use.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Atlantic Area

1.0210,
ENERGY EFFICIENCY AND UTILIZATION IN AGRICULTURAL PRODUCTION
M.A. Hellickson, South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Brookings, South Dakota* 57006 (SD00754)
OBJECTIVE: Evaluate systems for more efficient use of electricity, fossil fuels, and other energy sources for agricultural production. Determine the energy requirements for performing selected agricultural operations in South Dakota. Investigate methods of substituting energy sources, such as, solar and wind, for agricultural systems currently using conventional energy sources. Study the effects of management and control on energy use for agricultural production.
APPROACH: Cold air crop drying and solar supplemented crop drying studies will be conducted on the Agricultural Engineering Farm. Low temperature, low cost solar collectors will be investigated as a source of supplemental heat for confinement livestock buildings. Work will be performed to develop a multi-purpose solar-intensifier-thermal storage system for agricultural uses.
PROGRESS: A solar energy-intensifier system collected 51% of the energy available to a horizontal surface during the 14 test days from November 2 to December 21, 1977 and March 30 to 31, 1978. Using a diurnal tracking system with the solar energy-intensifier did not increase solar collection efficiency. Cost of the approximately 375 ft 2 collector system was $1541.60 for non-tracking and $2065.13 for tracking. A revised solar energy-intensifier system has been designed that is adaptable for both grain drying and livestock building heating. The major design modification involves the development of a single, integrated solar energy absorber and thermal energy storage unit. Field testing of this system will be initiated early in 1979. Numerous solar energy research installations were visited in Western Europe and in Oregon, California, New Mexico and one month was spent working as a member of the Solar Energy Research Division of the Los Alamos Scientific Laboratory as part of a six-month sabbatical leave program.
SUPPORTED BY South Dakota State Government

1.0211,
PREPARATION, PRESERVATION AND STORAGE OF LIVESTOCK FEEDS
R.M. Luther, South Dakota State University, Agricultural Experiment Station, Dept. of Animal Science, *Brookings, South Dakota* 57006 (SD00738)
OBJECTIVE: Determine effects of type of preparation, use of various preservatives and method of storage on rate of gain, feed consumption and feed efficiency of cattle and sheep under various feeding systems, digestibility, rumen fermentation and energy value of feeds and keeping qualities and nutrient losses during storage.
APPROACH: This project will involve a series of feeding trials using cattle and sheep along with digestion and metabolism experiments. The initial research will study the feeding value of corn grain harvested at high moisture and artificially heat dried, stored and dried with solar heat or treated with an organic acid preservative. Later studies will involve other high-moisture grains and the effects of preservatives and feed additives at time of storage or at the time of feeding with grains, forages and crop residues. Emphasis will be on making maximum use of grain and forage crops and residues for production of beef cattle.
PROGRESS: Two experiments on methods of harvesting and feeding oats as forage showed less harvesting loss (6-7%), more loss in storage (10-12%) but more cattle gains (24-48%) for low moisture silage (haylage) than for forage field dried and baled. Results indicate considerable variation in animal response. Likely factors involved are grain yield, quality of grain, protein content of forage and conditions as to weather and cattle. Corn grain fed at levels of 1.8 to 7.7 kg daily to cattle on pasture showed increasing gain with increasing levels of grain but a small response per unit grain in comparison to no grain controls. Rolled grain appeared to improve efficiency about 12% in comparison to corn fed whole with no consistent differences between level of corn fed. Other research in progress under this project is involved with evaluating oat grain in growing and finishing rations. Feeding and digestion trials are being conducted with various levels of oat grain in rations when the grain is fed whole or processed by grinding or rolling. Preliminary results indicate that oat grain is similar to corn in showing little benefit from processing when grain makes up a major portion of the ration.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, South Dakota

1.0212,
IMPROVING LARGE DAIRY HERD MANAGEMENT PRACTICES
R.K. McGuffey, South Dakota State University, Agricultural Experiment Station, Dept. of Dairy Science, *Brookings, South Dakota* 57006 (SD00860)
OBJECTIVE: Investigate ways of increasing the efficiency of producing dairy replacements in large herds. Improve animal performance and increase labor efficiency.
APPROACH: Various designs of calf hutches will be studied to determine the most efficient for providing added heat from solar energy. Calves three days of age will be housed in regular or solar-heated calf hutches and weight gain, feed intake and health determined. Physiological adaptation of young calves to extreme termperatures will be studied. Four free stall surfaces will be compared as to cow utilization and preference as well as labor requirements for cleaning and maintenance.
PROGRESS: Thirty-one Holstein calves (23F, 8M) received either whole milk (N) (N equal to 15) or fermented antibiotic milk (f) (N equal to 16) once daily beginning at 3 days of age. There were no differences in 0 to 4 or 4 to 8 wk gains of calves. Average daily gain from 0 to wk was .54 kg for both groups. Calves fed F tended to have greater (P greater than .10) starter consumption than calves fed N. Four surfaces, diet (d), perfa-lot (PL), bridge plank (BP), and concrete strip (CS) were installed into free stalls. Dry cows and heifers were observed AM and PL to determine usage. Order of preference was D, PL, CS, and BP. Free stalls were occupied as follows: D equal to 88%, PL equal to 79%, CS equal to 71%, BP equal to 50% of the time.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, South Dakota

1.0213,
DRAPERIES FOR THERMAL COMFORT AND ENERGY CONSERVATION
T.L. Vigo, U.S. Dept. of Agriculture, Agricultural Research, Textiles Clothing Research, *2005 Lake Ave., Knoxville, Tennessee* 37916 (7806-20860-015)
OBJECTIVE: Develop prototype draperies to optimize solar radiation and heat transfer at windows.
APPROACH: Employ window enclosures which effect temperature differences in winter and/or summer climates. Design and evaluate drapery prototypes which function as low temperature solar heat collectors and/or solar heat reflectors whereby thermal energy may be absorbed by or transferred from living spaces efficiently in winter and summer climates, respectively. Utilize laminates, coated fabrics, and other textile structures in draperies to produce desirable heat transfer properties and other characteristics important for achieving overall energy conservation on a seasonal level. Measure utility of drapes in relation to optimization of total energy transfer to living space and effects on accupant comfort parameters.
PROGRESS: Specifications were developed for an environmentally-controlled room which will serve as

a standard textile conditioning room and as an experimental temperature and relative humidity room for energy conservation research. A test window was installed at which large-scale drapery experiments may be performed with a Xenon-arc lamp light source to simulate solar radiation. Heat flow transducers are being employed in a draped window prototype to model heat flow properties related to drapery closure; minicomputers are being utilized to measure low millivolt potentials from heat flow devices and expedite heat flow assessments. No useable results were obtained on measuring fabric surface temperature with freshly prepared cholesteric liquid crystal films; commercially available encapsulated liquid crystal films having longer useable lifetimes and greater temperature sensitivity are being obtained.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Atlantic Area

1.0214,

DRYING LARGE HAY PACKAGES WITH SOLAR HEATED AIR

B.L. Bledsoe, University of Tennessee, Knoxville Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *W. Cumberland Ave. S.W., Knoxville, Tennessee* 37916 (7006-20190-018-A)

OBJECTIVE: Design, construct and test a modular dryer using solar heated air.

APPROACH: Basic module will be designed and installed into an existing multi-purpose pole barn. The module will have collector area and storage capacity to dry thirty 360-kg (800-lb) hay bales from 40 percent to 20 percent moisture content in 2 days or less. The dryer configuration will allow loading and unloading of bales without special handling equipment. The system will be evaluated by comparing solar dried haymaking with conventional haymaking (300-400 metric fons/year) and by drying corn (production from 40 ha/year) and providing heat for the machine repair storage area.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0215,

EVALUATION OF SELECTED PHYSICAL PROPERTIES AFFECTING HANDLING OF TENNESSEE VEGETABLES

L.R. Wilhelm, University of Tennessee, Knoxville Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *W. Cumberland Ave. S.W., Knoxville, Tennessee* 37916 (TEN00494)

OBJECTIVE: Develop reliable physical properties data for selected Tennessee vegetables. Apply the air flow data developed in this project to the design and operation of ventilafion cooling equipment for bulk cooling of vegefables being held for processing. Make these data available in a form which can be readily used in the design of bulk harvesting, handling, and transportation equipment.

APPROACH: Air flow resistance data, mechanical property data, and moisture measurement analyses will be made for several vegetable products. Resistance to air flow studies will be emphasized for snap beans, lima beans and southern peas. These tests will be coordinated with existing production research to insure full and effective use of the vegetables produced by those projects. Construct a bulk cooling system based upon the air flow data obtained. Test the system in cooperation with one or more Tennessee processors to evaluate its effectiveness in commercial applications. Presenf fhe results obtained in parts 1 and 2 at professional meetings and prepare the data for publication in appropriate technical publications.

PROGRESS: Measurement of resistance to air flow for bulk southern peas was continued and tests were initiated for lima beans. Tests indicate less satisfactory results than those obtained with earlier snap bean fests. Other factors such as product size and void space are being studied to improve the correlafion. As with snap beans, the correlation can be improved by including the bulk density in a dimensionless pressure term. Peas appear to have pressure drop characteristics very similar to snap beans while lima bean data show a slower increase in pressure drop with air flow. Three new solar dryer models were constructed and tested for apple drying. These half-scale models were tested in conjunction with a solar dryer and an electric dryer used in previous tests. All solar dryers appeared to work satisfactorily, although analysis of the data is continuing. Several varieties were used during these tests to determine the preferred varieties for drying. Analysis of these samples has not been completed. Limited tests of home oven drying are continuing to evaluate this method with respect to energy cost and product quality. Preliminary results indicate that energy costs are significantly higher when home ovens are used. Moisture measurement techniques for vegetables have been studied using snap beans as the test product.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Tennessee

1.0216,

CONTROL OF PLANT ENVIRONMENT IN FLUID-ROOF SOLAR GREENHOUSE

C.H. Van Bavel, Texas A & M University, College Station Campus, Agricultural Experiment Station, Dept. of Soil & Crop Sciences, *College Station, Texas* 77843 (7009-20690-022-A)

OBJECTIVE: Determine the feasibility of using thin film of selected fluids in the roof of a greenhouse to selectively absorb and store for later use, solar radiation not useful in photosynthesis by greenhouse plants.

APPROACH: Construct a dynamic simulation computer model that describes the energy disposition in a solar greenhouse with a fluid roof that is selectively transparent for photosynthetically active radiation. Evaluate the potential energy savings and other advantages of such a solar-heated, fluid-roof greenhouse. Add fluid circulation and storage to an existing greenhouse (23 m floor area) and install instrumentation to provide data for testing adequacy of model as well as comparison of effectiveness of various selective fluids.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0217,

INSECT SENSING DEVICES, MODELING, AND ENGINEERING ANALYSIS OF PEST CONTROL SYSTEMS

A.W. Hartstack, Texas A & M University, College Station Campus, U.S. Dept. of Agriculture Agricultural Research, Cotton Insects Research, *College Station, Texas* 77843 (7302-20302-001)

OBJECTIVE: Develop, improve, and evaluate insecf detection and control equipment and methods for use in operational pest management systems designed to control insect-pests (esp. Heliothis) in major field crops.

APPROACH: Traps will be designed and/or improved to monitor major pests, e.g., Heliothis, fleahopper, and boll weevil, as well as beneficial insects, e.g., Trichogramma, Chrysopa, ets., which are useful in protections Southern field crops from damage incurred by Heliothis, etc. Study and simulate the relationship of trap catches to actual population densities. Analyze and model key factors affecting population dynamics of important beneficial insects and improve the models of Heliothis population dynamics and crop growth (MOTHZV). Combine the models to study pest-beneficial-crop interactions.

PROGRESS: The computer based forecasting and information system of the Texas Agricultura Extension Service (BUGNET) used MOTHZV-2, a Heliothis population model, to provide timing forecast of Heliothis spp. peak egg lays in cotton at 15 locations in Texas during 1977. Forecasts were accurate within 2 days at 14 locations. Timing information proved useful as a managemenf tool for making decisions on schedules for scouting and treatments of pests. A new pheromone trap (the Texas Pheromone or TP-trap) was developed and tested. The frap is approximately 50% as effective as the electric grid frap, is simple and easy to construct, low in cost, easily portable and requires no electricity. Seasonal operation of virelure baited grid traps indicate cathces of male tobacco budworm moths tent to coindice with emergence of adults from the overwintered and the F1 generation. Competition with native females evidently causes trap catches to be low during F1 and F2 adult population peaks. Electric grid-type and 40-W BL insect traps were operated successfully from solar-powered electrical systems during 1he 1977 trapping season. A portion of the response and environmental data needed for development of a model describing performance of boll weevil pheromone traps was obtained at a non-cotton release site.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research

1.0218,

EVALUATION OF TECHNIQUES FOR DRYING AND STORING RICE TO MINIMIZE FUEL REQUIREMENTS

D.L. Calderwood, U.S. Dept. of Agriculture, Agricultural Research, Rice Res, *Rte. 5 Box 784, Beaumont, Texas* 77704 (7303-20590-001)

OBJECTIVE: Develop rice drying and storage procedures and equipment that minimize energy requirements while maintaining market quality.

APPROACH: Test drying procedures in laboratory and pilot plant investigations to determine combinations of heated-air temperatures and throughput rates that minimize gas and/or electrical consumption. Test solar heat collectors to supply heat for rice drying by direct application and by recharding desiccants. Determine the effect of additional field drying of selected rice varieties on yield, milling quality and grade by harvesting plots periodically during a 30-day interval as moisture content drops from 24 to 14 percent.

PROGRESS: A damper box and an additional fan were installed as components of a rock bed, solar heat storage system for drying rice in deep-bed dryer so that heat could be stored in the rock bed as a separate operation from drying rice with low humidity, unheafed air drying daytime hours. At nighf fhe heat was extracted from the rock bed. Although the number of days required to complete a drying operation with stored solar heat were fewer than with immediately applied solar heat during the 1978 harvest season, fan operating time and electrical energy consumption were greater. The head rice yield of rice dried with stored solar heat was lower than that of a control sample dried with unheatd air. Pulling all the air going into a plenum through a flat plate solar collection resulted in increasing the static pressure the dryer fan worked against. Air flow through the rice bed was less than for another dryer in which solar heated air at a lower velocity was mixed with ambient air at the fan entrance. More fan operafing time and electrical energy were required by pulling all of a dryer's air flow through the solar collector than by pulling only about one-fourth of the total air flow through a solar collector. Both long-grain rice variety, Labelle, and medium-grain rice variety, Nato, appeared to be well adapted for drying in the field to about 16% moisture content as a means of saving energy for drying otherwise needed for rice harvested at customary moisture levels of 20% to 22%.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Oklahoma - Texas Area

1.0219,

ENERGY CONSERVATION AND ALTERNATIVE ENERGY SYSTEMS IN RURAL AREAS

H.C. Petersen, Utah Higher Education System, Utah State University, Agricultural Experiment Station, Dept. of Economics, *Main Bldg., Room 104, Logan, Utah* 84321 (UTA00029)

OBJECTIVE: Determine the impact of higher energy prices on residents of rural areas. Assess current energy conservation practices in rural areas. Investigate the attitudes of rural residents with respect to energy conservation practices. Determine special problems associated with energy conservation in rural areas. Evaluate the economic feasibility of using alternative energy systems such as wind and solar in rural areas.

APPROACH: Data necessary to accomplish objectives 1-4 will be obtained from surveys of rural and urban residents in the state of Utah. Additional dafa will be obtained from utility records. Data will be analyzed using standard statistical methods. Objective #5 will be accomplished by collecting data from energy suppliers and existing studies. Using computer simulations and life cycle costing, the costs of building and operating solar and wind energy systems in rural areas will be determined. Also, interviews, a search of fhe literature will be used to determine special advantages and disadvantages of alternative energy systems in rural areas.

SUPPORTED BY Utah State Government

1.0220,

SOLAR SPACE HEATING DEMONSTRATION POND PROJECT

Unknown, Rutland Group Inc., *Rutland, Vermont* 05701 (EG-77-A-02-4423)

SUPPORTED BY U.S. Dept. of Energy

1.0221,
ENVIRONMENTAL IMPACT STATEMENT OF THE FEDERAL SOLAR AGRICULTURAL AND INDUSTRIAL PROCESS HEAT PROGRAM
J. Holmes, Energy & Environmental Analysis Inc., *1111 N. 19th St., Arlington, Virginia* 22209 (ET-78-C-02-4879)
SUPPORTED BY U.S. Dept. of Energy

1.0222,
SOUTH CENTRAL REGIONAL ASSESSMENT STUDY
O.H. Merrill, Science Applications Inc., *1710 Goodridge Dr., P.O. Box 1303, McLean, Virginia* 22102 (XP-9-8051-1)
The objective of this study is to identify opportunities for demonstration and follow-on large-scale use of solar electric systems (both central and dispersed) in the South Central region of the United States, during the time period 1980-2000, for a range of projected technical and economic characteristics for SE and non-solar systems, using inputs from potential owners of solar electric systems. The South Central region is defined as the states of Kansas, Missouri, Oklahoma, Arkansas, Louisiana, and Texas.
This study shall identify (1) potential solar electric options which are expected to be employed in specific segments of the region in the 1980-2000 period; (2) how and when each option might be employed by particular user groups; (3) key demonstrations that need to be taken to facilitate solar electrification in the region; and (4) a strategy for completing the actions which includes who should take specific actions and the roles of the federal and state governments in facilitating solar electrification.
Solar electric options for the study are photovoltaics, solar thermal electric, wind, OTEC and biomass.
SUPPORTED BY U.S. Dept. of Energy, Office of Solar Geothermal Electric & Storage Systems

1.0223,
SOLAR/WIND ENERGY TO COOL TOBACCO STORAGE WAREHOUSES TO PROVIDE INSECT CONTROL
F.A. Iachetta, University of Virginia, School of Engineenng & Applied Science, Dept. of Mechanical Engineering, *Garrett Hall, Charlottesville, Virginia* 22903 (7093-20620-004-A)
OBJECTIVE: Determine energy requirements for cooling and maintaining tobacco storages at 4 C during winter months and examine solar energy alternatives for powering either vapor compression or absorption refrigeration units to provide thermal conditioning and wind energy driven fans for air cooling and circulation.
APPROACH: Tobacco stored in representative sheet metal warehouse in central North Carolina will be monitored for rate of heat transfer. Heat emission from warehouse walls and roof will be measured, and methods selected to economically reduce this type of radiation. Size and cost of solar and/or wind powered cooling systems having capacity to chill warehouse air to cool tobacco packed in hogsheads be 4 C or lower for 12 consecutive weeks during winter months will be determined.
PROGRESS: A guarded hot plate apparatus was fabricated to establish a steady state, one dimensional heat flow in a cu ft of tobacco weighing 19 lb. The thermal conductivity of tobacco in the cube, using Fourier's laws, was 0.684 Btu/hr-ft 2 F/in. An apparatus was designed for measurement of the specific heat of tobacco. Electrical energy was delivered to an aluminum plate located in the mid-plane of a 19.9 cu ft block of tobacco as thermal energy. Specific heat of tobacco was computed by measuring temperature increase vertically from the plate with a measured quantity of electrical energy. A value of specific heat, acceptable for use in the computer modeling of tobacco storages, was found to be 0.67 Btu/lb degrees F. Two tobacco hogshead, racked either vertically or horizontally, were subjected to a step change in temperature in constant temperature controlled rooms. The cool-down and heat-up thermal responses of tobacco in hogsheads in the horizontal and the vertical orientations are sufficiently rapid to be considered stable after 15 and 20 days, respectivelyt. Temperature measuring equipment was installed in a tobacco warehouse. Observations in the storage correspond with the predictions of theory confirming thermal conductivity and specific heat valves are valid for purposes of this research. A computer model is under construction.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Atlantic Area

1.0224,
WASTE SYSTEMS AS SOLAR ENERGY RESERVOIRS
D.H. Vaughan, Virginia Polytechnic Inst. & State University, School of Agricultural & Life Sciences, Dept. of Agricultural Engineering, *Blacksburg, Virginia* 24061 (VA-0333903)
OBJECTIVE: Evaluate waste treatment systems such as lagoons as solar energy storage reservoirs, evaluate types of solar collectors for heating lagoons, and develop and evaluate methods for recovery of heat from waste systems through use of heat pumps.
APPROACH: Solar collectors for heating fluids such as found in waste treatment lagoons, will be designed, and used to heat an existing lagoon. Heat pump systems for recovery of energy stored in the lagoon will be designed and used for space heating of a livestock shelter. Overall performance of the system will be evaluated by comparing performance with and without the solar energy input.
PROGRESS: A solar assisted heat pump system using a thermal storage pond was used to heat a swine nursery (2.4 m multiplied by 4.9 multiplied by 2.4 m high) for raising pigs (three groups and 36 pigs/group) during Winter 77-78. Water, heated by solar panels (15.52 2) , was circulated through the inlet coils of a water-to-air heat pump to heat the building An insulated, covered water pond, which could be inexpensively constructed by a farmer using available building materials and equipment, was used for storage of solar heat for use with the heat pump at night and during cloudy periods. System operation temperatures, electric power usage, and solar radiation were recorded during the tests. Pig health and growth were comparable to other housing methods using conventional heating systems. Measured COP values for the heat pump and overall system were 2.63 and 2.04, respectively. For a COP above 2, the operating cost for this solar assisted heat pump system is comparable to other conventional heating systems using fossil fuels and significantly better than electric resistance heating. Initial investment for the heat pump system is, of course, greater. Storage pond temperatures ranged from about 5 to 35 degrees C for ambient outside air temperatures down to minus 19 degrees C.
SUPPORTED BY Virginia State Government

1.0225,
IMPROVED SYSTEMS FOR HARDWOOD LUMBER DRYING
E.M. Wengert, Virginia Polytechnic Inst. & State University, School of Agricultural & Life Sciences, McIntire Stennis Program, *Blacksburg, Virginia* 24061 (VA-0632323)
OBJECTIVE: Improve efficiency of hardwood drying and reduce fossil fuel use by: Testing methods for improved control of lumber dry kilns. Evaluating solar, dehumidifying and high temperature dryers. Evaluating pre-treatment methods to prevent end splitting. Developing data for assessing cost of all alternatives in drying systems tested.
APPROACH: Test process control by acoustic emissions, electrical resistance, and direct measurement of weight loss in new experimental kiln just installed at VPI. At site of industrial cooperator and at VPI end-coat tests and control with was emulsion and other materials prior to kiln drying. At site of industrial cooperator and at VPI evaluate solar predryer, dehumidifying, predryers, and high temperatures (100 and above). Cooperators will keep cost data on drying methods tested on industrial-size kilns.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Virginia

1.0226,
QUALITY HOUSING ENVIRONMENT FOR LOW-INCOME FAMILIES
H.T. Hurst, Virginia Polytechnic Inst. & State University, School of Architecture & Urban Studies, Dept. of Environmental & Urban Systems, *Blacksburg, Virginia* 24061 (VA-0623215)
OBJECTIVE: Identify housing related aspirations, expectations, needs and satisfactions of low-income families and examine limitations to the attainment of quality housing. Formulate and evaluate innovative delivery systems in production, marketing, and financing in order to improve housing conditions. Develop and determine the acceptability and economic feasibility of innovative designs including housing components, new combinations of materials, and building techniques, such as peripheral heating systems and modular panels.
APPROACH: Assess relationships between social environment and: income use, social satisfaction, health, age, and tenure of low-income families and physical environment and: restraints by financiers, codes, unions, and producers of housing. Evaluate relationships between in-place costs, acceptability and adequacy of new or existing house and/or component designs.
PROGRESS: Statistical analysis completed on preferred neighborhood and community characteristics. Selective analysis in progress on: community services (water/sewage), protection (fire/police), environmental and non-financial constraints to acquiring quality housing. Writing to be completed by July, 1979. Perception of housing adequacey as influenced by ownership access and race being prepared for presentation at '79 Conference of Am. Home Econ. Assoc. Articles and Bulletins on all of above in progress. Presented accomplishments of regional research in housing in past 60 years at housing conference at U. of Tenn, Knoxville, TN. Presented and emphasized housing research results at a regional workshop on low income family housing. Developed proposals with ARC and HUD funding for 15 solar heated homes in TN, KY, and Pa. Applied research results to a 4-bedroom house in which material costs were reduced 37% of FmHA homes. It will be monitored for satisfactory performance. Developed a tri-level multi-family design for active and passive solar heating, with primary entrance on middle level, adaptable to sloping lots, has 4-6 units/building, 2-4 bedrooms/unit and utilizes research results to reduce material costs $5,000/building. Utilization of above research findings will help decision-makers, developers and producers in providing quality housing to low-income families.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Virginia

1.0227,
HOUSING FOR LOW- AND MODERATE INCOME FAMILIES
H.T. Hurst, Virginia Polytechnic Inst. & State University, School of Architecture & Urban Studies, *Blacksburg, Virginia* 24061 (VA-0622332)
OBJECTIVE: Provide innovative designs and research assistance for the construction of prototype housing systems and subsystems and for rehabilitation of existing housing and review and evaluate them by interdisciplinary teams; determine societal constraints to the adoption of housing alternatives, including those of finance, cost, regulations, policies, land use and energy use; determine constraints within the family to the adoption of housing alternatives including demographic characteristics, family resources, family decision-making processes and consumer acceptance; develop effective methods of disseminating housing research information to consumers and key decision-makers in the area of housing.
APPROACH: Conduct evaluative studies to compare prototype houses with selected standard houses for design, material cost, equipment, and energy consumption. Design and administer consumer-responsive questionnaires. Conduct case studies on adoption of housing innovations, residential solar energy technology, and other alternatives by interviewing officials, experts producers, consumers, and financiers. Evaluate housing information networks, assist in preparation of housing workshop guidelines, and support state/regional workshops.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Virginia

1.0228,
COMBINATION DRYING OF GRAIN USING SOLAR ENERGY
J.L. Baker, Virginia Polytechnic Inst. & State University, School of Engineering, Dept. of Agricultural Engineering, *Blacksburg, Virginia* 24061 (3090-20592-031-G)
OBJECTIVE: Develop a combination drying system utilizing solar energy suitable for use in the humid Southeast. Develop solar collector designs suitable for installation in farm building roofs which will be economical, have long life, be useful for multiple applications & easily constructed. Evaluate and demonstrate such combination systems for drying crops under humid conditions.
APPROACH: Select two farmsteads having or planning high-temperature drying systems and storage bins and alter or build these into combination systems incorporating solar drying. Design & build solar collectors integrated into south-sloping roofs. Design criteria shall be 15-yr useful life, material costs of less than $2/sq. ft. of area, & average efficiency of at least 50% when used for grain drying. Construction shall be possible by farmers or farm builders

Evaluate and demonstrate the use of solar energy in grain drying applications.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Illinois - Indiana - Ohio Area

1.0229,
PROOF OF CONCEPT OF TWO NOVEL SOLAR HEATED GREENHOUSES

D.B. Straub, Ecotope Group, *747 16th Ave. E., Seattle, Washington* 98112 (12-14-7001-1031)
The objectives are to design, demonstrate, and evaluate the concept of low-cost passive solar heating of greenhouses for use in area of limited space or water utilizing passively controlled ventilation/cooling systems and integrated plant and aquaculture production. The approach is to construct and test a parabolic greenhouse with a floor area of 360 sq-ft., reflective and insulated parabolic north wall, a 5000-gallon pond of water for solar energy storage and a growth area for fish (tilapia), and a thermal ventilation stack 20 feet high; monitor the environmental and biological systems and compare theoretical and actual performance to specify equations describing transient behavior of the greenhouses; and use performance data to improve and optimize designs for passively heated and cooled greenhouses and maximizing greenhouse production.
SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Div. of Solar Energy, Office of Solar Application for Buildings

1.0230,
PHYSIOLOGY AND CULTURE OF HIGH QUALITY HOPS

C.E. Zimmermann, U.S. Dept. of Agriculture, Agricultural Research, Irrigation Agricultural Research & Extension Center, *Prosser, Washington* 99350 (5806-20010-002)
OBJECTIVE: Study physiology of the hop plant, develop improved production practices, and test hop varieties and selections for adaptation to irrigated hop producing areas.
APPROACH: Studies on gland and cone develpment will be conducted in greenhouse and field with virus-free and infected clones. Determinations of total soft resins, oil content and oxidation products will be made in laboratory with lupulin glands. Field studies will be carried out to develop improved cultural practices under a low trellis design. Domestic and foreign varieties and advanced selections from breeding programs will be evaluated for agronomic and chemical characteristics and disease and insect resistance to identify clones adapted for hop production under irrigation in the hot, dry interior valleys of the Pacific Northwest.
PROGRESS: Forty-five advanced hop selections were submitted to five brewers for evaluaion as aroma and extract types. Commercial plots of advanced lines established in Californa and Yakima valley. Forty selections made of lines adapted to low trellis system. Application of gibberellic acid increased cone number of Bullion hops. Tettnanger yield three times greater on low trellis than conventional system. Granular Temik applied to hop hills, at three pounds active per acre, under sprinkler irrigation effect in control of aphids and mites. Solar drying of hops reduced oil consumption by 7%. Reduction in hop oil and alpha-acids highest at bottom of hop drying bed. Oxidation rate of alpha- and beta-acids during storage varies with hop cultivar.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Oregon - Washington Area

1.0231,
UTILIZATION OF SOLAR ENERGY IN FOOD PROCESSING

D.C. Davis, Washington State University, College of Agriculture, Dept. of Agricultural Engineering, *Pullman, Washington* 99163 (WNP00403)
OBJECTIVE: Characterize energy use of specific unit processes that are important to the food processing industry of Washington State, characterize solar energy availability at representative locations that are important centers for food processing in the state, determine the potential for solar energy use at specific processing sites and necessary energy storage capacities, adapt existing processes or develop new processes that can efficiently utilize solar energy for food processing, determine minimum thermal processing requirements of foods while providing reasonable safety margins, evaluate the safety, quality, and storage stability of food products processed with solar energy.
APPROACH: Published literature, personal communication, and field data collection will be used to obtain data for objectivess 1 and 2. Processing operations and solar radiation characteristics will be studied together to define appropriate solar collection and storage systems. Technical and economic factors will be evaluated for solar energy systems. Where process modification are needed to utilize solar energy efficiently, investigations into new or improved processes will be conducted. Equipment will be constructed and tested to evaluate these processes.
PROGRESS: Activity has focused primarily on objectives 1 and 2. Defining energy requirements of food processing operations and locating sources of solar energy data for the state. A review of literature on applications of solar energy to food processing is in progress. Information on energy use in some major food processing operations in the state has been obtained. State and national weather data sources have been contacted to identify official sources of solar radiation records. Investigation into solar collector types and their suitability for use in food processing operations has been initiated. Correspondence with manufacturers has resulted in the identification of some collectors that may be suitable.
SUPPORTED BY Washington State Government

1.0232,
SOLAR-ASSISTED DRYING OF HOPS

G.A. Kranzler, Washington State University, College of Agriculture, Dept. of Agricultural Engineering, *Pullman, Washington* 99163 (7003-20190-015A(1))
OBJECTIVE: Investigate by field study the technical and economic feasibility of utilizing solar energy as a supplemental thermal source for the drying of hops by means of: Preheating ambient system intake air and conditioning kiln exhaust air for system recirculation.
APPROACH: A portion of the roof of an existing conventional design multi-kiln hop drier plant will be modified to serve as a solar collector. The collector design will permit preheating outside air or conditioning and recirculating kiln exhaust air. Both modes of operation will be evauated and energy conserved will be determined by comparison with a second unmodified kiln.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0233,
DIRECT PASTEURIZATION OF FRUIT JUICES USING SOLAR ENERGY

D.C. Davis, Washington State University, Graduate School, *Pullman, Washington* 99163 (7003-20510-019-A)
OBJECTIVE: Determine technical feasibility of using solar energy for direct pasteurization of fruit juices. Develop recommendations for designs of solar collectors suitable for fruit juice pasturization and determine effects of direct solar radiation exposure on product.
APPROACH: Survey commercial and experimental solar collector designs and select most feasible for direct food product pasteurization. Analyse available solar energy in Washington fruit processing regions and relate to energy needs for pasteurization. Measure minimum time-temperature parameters for safe pasteurization of fruit juices. Measure absortivities of different light wave lengths and test relative effects upon fruit juice sterilization and product quality (including color, nutrients and flavor).
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0234,
ENERGY USE IN MARKETING AND PROCESSING FOOD AND FIBER COMMODITIES

L.F. Rogers, Washington State University, U.S. Dept. of Agriculture Commodity Economics Div., Poultry Products Program Area, *Pullman, Washington* 99163 (CE-08-077-53-01-X1)
OBJECTIVE: Develop estimates of energy required in marketing food and fiber commodities, present and future. Conceptualize and develop analytical models for aggregating and disaggregating energy data and studying alternatives relating to energy forms, locational, geographical and seasonal problems, commodity shifts, and long-range programs. Analyze potential energy use with alternative marketing methods, new technology, and conservation practices. Determine effects of modification of regulations on energy use by agricultural marketing firms and of national and international energy policies on costs, prices, location of production and marketing functions, and commodity mix. Suggest policy alternatives which would maintain a viable agriculture.
APPROACH: Develop estimates of energy use in the marketing of selected food and fiber commodities. Conceptualize and test an accounting model for measuring energy use in agricultural marketing and evaluate potential energy requirements with alternative marketing systems. Estimate State energy requirements for marketing by type of energy, season, commodity and function. Study effects of modified transportation and environmental regulations. Develop structural profiles of agricultural marketing firms with inputs and cost measurements.
PROGRESS: Available energy data and studies were reviewed. Schedules and plans for survey of energy use, conservation, and practices in marketing all food and fiber commodities were completed and analysis was begun. A framework for marketing energy data base was developed. A report on energy use and costs in Southern broiler processing plants was published. Data on energy use and costs in rendering poultry products was analyzed and a report was published on solar grain drying systems.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Commodity Economics Div.

1.0235,
SOLAR HEATING W/BUILT IN WOOD FIRED BACKUP SYSTEM FOR INST. ON A MOBILE HOME

R. Himmelmann, (No Performing Organization Reported), *Wisconsin*
SUPPORTED BY U.S. Dept. of Energy

1.0236,
UTILIZATION OF SOLAR ENERGY IN CHEESE PROCESSING OPERATIONS

D.B. Lund, University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Food Sciences, *116 Agricultural Hall, Madison, Wisconsin* 53706 (7093-20530-003-A)
OBJECTIVE: Analyse energy reuse in cheese processing, determine feasibility of heat exchanger network for energy conservation, develop system changes to maximize solar energy augmentation in a cheese processing system.
APPROACH: Select plants to study based on product and process diversity and production capacity. Develop strategies for energy use and reuse within selected systems. For a selected cheese plant, design and develop an optimum heat exchanger network for maximum energy utilization. Develop solar collection systems to augment hot air or water using solar collection and storage system which is most attractive economically.
PROGRESS: Five separate cheese plants were studied to analyse energy use and reuse possibilities. Values of gross energy demand, milk consumption and cheese consumption weredirectly taken from plant records over the past two years. Gross energy demands of plants were further broken down by performing microscale energy analysis within each plant. They were characterized by unit operations for those which require hot water, including boilers, pasteurizers, cooling and blending vats, and cleaning systems. Mass flow rates and temperatures in each unit operation were measured directly or calculated by mass and enthalpy balance. These energy analyses were based on assumption of steady state conditions in plants. Based on these studies, recommendations have been made for designing a heat exchanger network by which heat losses and waste heat can be minimized and heat can be conserved within the plants, making it more feasible to supply a significant amount of required energy input by solar heat, generated in hot water collectors.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0237,
ECONOMIC ANALYSIS OF SOLAR ASSIST IN FOOD DEHYDRATION

D.B. Lund, University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Food Science, *116 Agricultural Hall, Madison, Wisconsin* 53706 (7002-20510-018-A)
OBJECTIVE: Assess economic feasibility of solar-assist food processes. Determine theoretical energy demand model which would result in economically viable system. Recommend food drying operations which can result in systems more compatible with solar energy use.
APPROACH: Collect energy demand information from six dehydrated-food projects on the national DOE research program. Using transient simulations of solar supply, collection and storage, identify dehy-

dration process modification needed to improve efficient usage of solar energy in those processes. Recommend changes in direction of current on-going research projects and potential needed new projects for optimum use of solar energy in food dehydration.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

1.0238,
FISH MEAL FROM SOLAR HEATED DRIERS
B. Jicks, (No Performing Organization Reported), *Caroline Islands* (EM-78-G-03-1976)
SUPPORTED BY U.S. Dept. of Energy

1.0239,
TYPHOON-PROOF SOLAR GREENHOUSE OF TROPICAL AGRICULTURE
E.P. Leroy, (No Performing Organization Reported), *Guam*
SUPPORTED BY U.S. Dept. of Energy

1.0240,
DRYING AND STORING OF RICE
M.A. Sabbah, Gameat Al Iskandaria, *Alexandria, Egypt* (8005-20590-001)
OBJECTIVE: Determine characteristic drying rates and moisture equilibria for rice grown in Egypt; establish requirements for drying rice with natural air and with solar heat; develop indices for measuring rice deterioration.
APPROACH: Using standard techniques, measure the characteristic drying rate and equilibrium moisture content of rice fully exposed to air of selected temperatures and relative humidities. Measure direct and diffuse solar radiation and explore its application for drying rice. Develop deterioration indices based on temperature-moisture-time relationships and dry matter losses for use in evaluating in-storage drying procedures.
PROGRESS: The research on 'Drying and Storing of Rice' was implemented in December, 1977. No research was conducted in 1977. However, some grain was purchased in preparation for laboratory tests.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Great Plains Area

1.0241,
A COORDINATED RESEARCH PROGRAM ON OPERATIONAL RESEARCH IN SOLAR ENERGY UTILIZATION IN AGRICULTURE
H.P. Garg, Central Arid Zone Research Inst., *Jodhpur, India* (8001-2190-142)
OBJECTIVE: To investigate the utilization of solar energy for drying crops, producing potable water and providing supplemental heat for increasing the production biomass.
APPROACH: Design criteria will be developed for solar crop dryers, solar stills and solar cookers. Hardware will then be assembled and the units tested to determine the technical and economic feasibility. The dryers will be used on crops such as maize, rice, peanuts, mustard seed and vegetable crops. The solar stills will be evaluated for the production of potable domestic water from saline water and water which is otherwise unfit for drinking purposes. Solar cookers will be evaluated for their potential in reducing other energy inputs in the cooking of food. Solar energy will be applied to gobar gas plants in the winter and the production of this unit will be compared with that of similar plants without the solar assist. This research will be conducted at 5 seperate locations in India.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

1.0242,
STUDIES ON THE DEHYDRATION OF FISH AND OTHER MARINE PRODUCTS
K.M. Apolinario, National Inst. of Science & Technology, Food Research Dept., *P.O. Box 774, Manila, Philippines* (PCARR 704)
OBJECTIVES: 1. To find the proper combination of artificial drying and sun drying techniques that would yield a highly acceptable dried-fish product at a minimum cost. 2. To determine the optimum salt concentration for the treatment of fish as suggested by previous workers that would yield the desired product quality and storage life upon dehydration using the technique developed above. The packing requirements and storage stability of the developed product will also be determined. 3. To conduct pilot plant scale operation on the developed process and the cost analysis of the process developed for commercialization; and to provide data for future studies.
APPROACH/METHOD: The fish species that will be used are those that are abundant, popularly consumed, and have commercial and export potentials (such as tamban, tunsoy, besugo, etc.). The time and place of collection will depend on the availability of samples.
The samples that will be collected will be assessed in terms of: appearance, odor, volatile base (TMA), volatile reducing substances, microbiological analysis and proximate analysis. Salting pretreatments as developed by other workers will be tried. An NIST fabricated artificial dryer and the traditional sundrying technique will be used. Salted fish products will be physically, chemically, and microbiologically examined.
The storage and shelf-life of the product will also be studied.
SUPPORTED BY Philippine Council for Agriculture & Resources Research

1.0243,
IMPROVED METHODS OF HANDLING AND PROCESSING FISH CATCHES IN MUNICIPAL FISHERIES
F.M. Orejana, University of the Philippines, College of Fisheries, Dept. of Fish Processing Technology, *Diliman, Quezon City, Philippines*
OBJECTIVES: 1. To investigate existing fish handling, processing and distribution practices on board municipal vessels and on shore to estimate avoidable losses from such practices. 2. To help solve current problem by conducting applied research aimed at reducing waste in fish catches. 3. To specify required facilities and equipment for improved handling, processing, distribution of fish, initial investment and operation cost, particularly for solar drying, small-scale smoking and home canning. 4. To propose detailed programs for the implementation of recommended improvements by conducting local and short-term training for municipal fishermen.
APPROACH/METHOD: 1. Select at least three (3) landing places in fishing community in which detailed studies will be carried out. 2. Set up a work team who will implement the research program. The work team will study the prevailing methods of handling, processing and quality control of fish catch from municipal fisheries. 3. Investigations will be made on the quantity and nature of fish catch, icing techniques and quantity changes during transport of iced wet fish in small fishing vessels and during distributions. 4. The use of various types of containers shall be investigated showing the correlations between quality changes and types of fish boxes. 5. Fish processing techniques will be employed, taking into consideration the processing scale in the selected pilot areas (family or cottage industry). 6. Studies shall be conducted on the facilities, equipment and infrastructure required to improve existing conditions in the selected pilot area. 7. Short-term training courses for municipal fishermen and others involved will be conducted to facilitate technology transfer to the fishing communities.
SUPPORTED BY National Science Development Board

1.0244,
ENERGY PLANNING BY LOCAL GOVERNMENT WITH REGARD TO RENEWABLE ENERGY SOURCES - PROGRAM
B.W. Sahlberg, Nordiska Institutet for Samhallsplanering, *Skeppsholmen, S11149 Stockholm, Sweden* (780089-9)
The rapid introduction of renewable energy sources makes new demands on planning resources, including energy planning by local government. It must be possible to evaluate and compare alternative systems. The present project aims to develop planning oriented methods for measuring and estimating the potential of the renewable energy sources at action area level, i.e., micro level, with regard to topography, soil characteristics, land development, season etc. The energy forms dealt with are: solar energy, wind energy, and heat extracted from the air, water and earth.
A good deal is known about these different fields, but our knowledge is not systematized for application in the planning process. The starting point of this project is therefore to link up materials and techniques from different sources, e.g., meteorological and hydrological statistics with techniques from air photo interpretation/map analysis and methods for calculating energy flows at different angles of radiation incidence, heights, temperatures etc. Special studies to be carried out where necessary to supplement existing material and techniques.
Methods developed in this project will be tested in the planning situation in a selected municipality and evaluated by field studies in the municipality. The aim is to be able to integrate the project results smoothly into the material underlying local government energy planning.
SUPPORTED BY Statens Rad for Byggnadsforskning

2. WIND ENERGY

2.0001,
WIND ENERGY SYSTEMS DEMONSTRATION PROGRAM
W.C. McConkey, State Div. of Energy & Power Development, *338 Denali St., Anchorage, Alaska* 99501
The following wind demonstration projects are in the planning stages: 1. The Nelson Lagoon project will provide electrification for the entire village with several wind generators. The generators, as with the other two projects, will be backed up by a diesel generation system. This small fishing community is located on the Alaskan Penninsula, near the Aleutian Chain, where abundant wind exists. The village now has electricity supplied by individual generators. 2. The Cold Bay site is not far from Nelson Lagoon, and with a large state owned airport, uses considerable expensive power. The project will tie into the existing power grid and will have the support and help of the local power utility, Northern Power and Engineering Corporation. We will be testing vertical axis machines being used at other sites. 3. The Kotzebue project will provide an excellent opportunity for on-the-site education in operation and management of wind systems, as it will be located at the Kotzebue Community College facility. This project will be located in the Northwest part of Alaska, giving us the opportunity to study the effects of severe cold and ice, while the Alaskan Penninsula projects will test the effects of salt spray deterioration, rain and high gusting.
SUPPORTED BY Alaska State Government

2.0002,
WIND DEMONSTRATION PROJECT, NELSON LAGOON, ALASKA
C.M. Quinlan, State Div. of Energy & Power Development, *338 Denali St., Anchorage, Alaska* 99501
This is a state-sponsored wind demonstration program designed to show operating characteristics and costs of wind generator providing direct power input to a utility system in a remote Alaskan location. A 20 kw Grumman Windstream generator feeds power through a synchronous inverter directly into a power system serving all village loads (school, residences, fish processing plant) supplementing 60 kw of diesel generating capacity. The operators are monitored to develop necessary data on operating characteristics and costs. Costs include site selection study and installation of power distribution facilities, as well as installation of wind generator and monitoring. This demonstration project addresses a problem shared by many remote Alaskan villages which are now dependent on costly, imported diesel fuels. Their energy options are very limited, but wind power potential looks promising for many sites. There is likelihood of a near-future use of several hundred wind generators in this application when the technology is proven.
SUPPORTED BY U.S. Dept. of Energy

2.0003,
WIND POWER FOR WELL PUMPS
Unknown, Contra Costa Water District, *Concord, California* 94524 (EM-78-G-03-1997)
SUPPORTED BY U.S. Dept. of Energy

2.0004,
MESOSCALE WIND PATTERN ANALYSIS AND MODELLING
K.K. Wagner, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Land Air & Water Resources, *Davis, California* 95616 (CA-D#-LAW-3463-H)
OBJECTIVE: Develop an objective numerical method to analyze mesoscale wind pattern in the Central Valley and adjacent areas. With this analysis method, the historical wind data will be analyzed to construct mesoclimatic wind patterns. The feasibility of extrapolating mesoclimatic wind patterns from the current climatic data will be determined.

APPROACH: The wind pattern analysis will be a numerical variational analysis, a technique which combines observational data with a model of atmospheric structure. The atmospheric model will extend the analysis to regions not covered by observations. The analyses of wind data from the Central Valley will be averaged to produce a mesoclimatoloty of wind. A comparison of these wind patterns with those derived from analyses of climatic averages will determine the feasibility of extrapolating the mesoclimatology from the currently available climatology.
PROGRESS: A study of the variation of grid resolution in a surface wind flow model found that a two kilometer grid size was needed in the model when using the model in the Lake Tahoe region. The model was more successful in accounting for terrain effects on the wind flow than it was in simulating thermal effects. The region of study of wind flows within complex terrain is being moved to the geothermal energy area in Northern California. Comparisons of model output and measurements are planned.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

2.0005,
WINDMILL-POWERED HEAT PUMP IN A DAIRY OPERATION
R.N. Meroney, Colorado State University, School of Engineering, Dept. of Civil Engineering, *Fort Collins, Colorado* 80523 (1090-20401-004-A)
OBJECTIVE: Gain more needed experience from operating a windmill system, and determine the technical and economical fesibility of a windmill-driven heat pump for a dairy operation.
APPROACH: A vertical-axis windmill has been constructed and connected electrically to the milk cooling-water heating system at the Colorado State University dairy farm. It has been instrumented and some data has been taken. Data will be continuously taken during the agreement. It will be summarized and included in a report at the end of the project.
PROGRESS: Operation and control of the Darrieus rotor wind turbine at Colorado State University was assumed by the Colorado State personnel. A small improvement in power produced has been achieved by modifications in the system. The performance tests will continue. The gear box will be modified to increase rotor speed, and blades will be modified to give more streamlined airfoil. Long-range performance tests will continue under new conditions.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Beltsville Agricultural Research Center

2.0006,
A WINDMILL POWERED HEAT PUMP IN A DAIRY FARM APPLICATION
G.B. Curtis, Kaman Sciences Corp., *1700 Garden of the Gods Rd., Colorado Springs, Colorado* 80907 (1090-20401-003-C(1))
OBJECTIVE: Design, construct, and operate a windmill powered generating system adapted to the existing dairy facilities at Colorado State University, Fort Collins, Colorado, to cool milk and heat water; measure thy performance of the system as it relates to local wind conditions; and make an economic, cost, and value analysis of wind utilization in cooling milk and heating water for a dairy operation.
APPROACH: A commercially available 20-foot diameter, vertical axis wind turbine will be purchased and installed to provide wind generated electrical power to operate an existing ice builder refrigeration compressor at the Colorado State University (CSU) Experimental Dairy Farm at Fort Collins, Colorado. The CSU facility will be modified to operate the existing system as a heat pump. Other modifications will be made to transfer the heat to water for sanitation. Measurements will be made on wind conditions and the operating performance of the wind energy system. They will develop a computer model for the performance and cost analysis of the research system adapted to other sizes, locations, and applications. Periodic oral and written reports will be prepared followed by a final report at the end of the study.
PROGRESS: The Darrieus rotor wind turbine installed at the Colorado State University continued operation with system performance evaluation being made. The contract expired. Instruction was given to Colorado State personnel to continue operation, and modifications were made for simpler operation. The Final Report is being reviewed and is expected to be finalized in the near future.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Beltsville Agricultural Research Center

2.0007,
ECONOMIC ANALYSIS OF WIND-POWERED FARMHOUSE AND FARM BUILDING HEATING SYSTEMS
R.W. Stafford, Regional Systems Services Group, *Englewood, Colorado* 80150 (3090-20691-003-C)
OBJECTIVE: Determination of the economic potential for use of wind energy conversion systems (WECS) for the heating of farm buildings.
APPROACH: Identify principal heating requirements in agriculture; determine duration and size of heating load for principal heating requirements identified; determine size distribution of heating units now used, classifying data for present energy sources by regions having same average wind speed and similar heating requirement; estimate cost of heating with present energy sources by using average yearly heating loads for regions of similar heating requirements and using multiple levels of energy costs; determine specific farm building heating applications that wind power could satisfy considering effect of wind variability on system power requirements, suitabillty of a specified finite energy source system that would not exceed storage period required for solar heating, ability of wind-powered system to serve as self-sufficient system, or as a supplemental source of heat, and the effect of nonuniform electric rates on the practicality and economic value; estimate cost of wind-powered heating systems that would breakeven with present heating systems; and compile estimates of the number of potential users for each costs levels.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Great Plains Area

2.0008,
TECHNICAL SERVICES/FEASIBILITY STUDIES II - SOLAR AND WIND ENERGY APPLICATIONS
Unknown, Solar Energy Research Inst., *1536 Cole Blvd., Golden, Colorado* 80401 (276-0005)
The Solar and Wind Energy Applications project in the Syrian Arab Republic is designed to make a preliminary assessment of possible solar and wind energy electrical generation, with emphasis on remote site application. Recommendations for a program of action for a solar energy research center will be made considering applied research and demonstration projects in the context of strategy development. The equipment will be assessed and a long-term technical assistance plan will be developed with focus on laboratory requirements.
SUPPORTED BY U.S. International Development Cooperation Agency, Agency for International Development

2.0009,
REMOTE SENSOR FOR WIND ENERGY
W. Hooke, U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin., Environmental Research Lab., *Boulder, Colorado* 80302 (RAA77070)
PROJECT OBJECTIVE: To provide a review of remote sensing devices and their potential for wind energy studies, ex: among all-weather capability, range and resolution, accuracy, spatial and temporal sampling rates. To summarize the stage of development of the sensors, the level of expertise required for their installation and cooperation, etc.
CURRENT YEAR PLAN: To develop material for the required review, through: 1) Literature search, 2) Interviews with WPL staff, 3) Interviews with other ERL staff and with outside groups (nationally).
SUPPORTED BY U.S. Dept. of Energy

2.0010,
WIND ENERGY STUDIES
J.C. Kaimal, U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin., Environmental Research Lab., *Boulder, Colorado* 80302 (RAA73379)
PROJECT OBJECTIVE: Measurement of turbulent wind statistics for use in design of wind turbine generators.
CURRENT YEAR PLAN: Obtain joint probability distributions of the three velocity components and the accelerations of the wind components.
SUPPORTED BY U.S. Dept. of Energy

2.0011,
ENERGY STORAGE
L.G. Ostermann, General Electric Co., Center for Energy Systems, *777 14th St. N.W., Washington, District of Columbia* 20005
Various projects involving energy storage including: batteries, wind conversion, photovoltaic conversion, latent heat storage, hydrogeneration, and compressed gas storage.
SUPPORTED BY U.S. Dept. of Energy

2.0012,
OPTIMIZING WATER PUMPING WITH WIND ENERGY
D.E. Avery, (No Performing Organization Reported), *Hawaii* (EM-78-G-03-1908)
SUPPORTED BY U.S. Dept. of Energy

2.0013,
UNIVERSITY OF HAWAII ENERGY HOUSE
J.E. Pearson, University of Hawaii System, Manoa Campus, Graduate School, *Spalding Hall, Room 359, Honolulu, Hawaii* 96822
A demonstration dwelling is being constructed in order to promote public awareness of (1) energy conservation in the home through the use of natural ventilation and lighting, alternate energies (solar and wind), energy saving appliances and waste heat capturing; (2) the importance of climatically appropriate building design for sun and wind control, material conservation and maximum human comfort; (3) resource conservation in terms of building materials, water collection and use and recycling of materials and wastes. The project will also provide the State with a comprehensive study of energy conservation in housing.
The house, located on the Manoa Campus, is particularly designed for the Hawaiian climate with an emphasis on natural ventilation and lighting. Appliances have been selected to provide the customary modern conveniences including dishwasher, with the minimum amount of external power. The architectural design, with a sheltered deck on all sides, provides for comfortable indoor-outdoor island living at low-to-moderate cost.
An economical, dependable temperature measuring sensor has been devised for the monitoring systems. A telephone circuit will be leased to link the Energy House with the computer terminals for recording and analyzing data. The information will be digitized and returned to a teletype printer located at the Energy House for print out display to visitors. Twelve Kwh meters will provide integration of electric uses throughout the house. Instrumentation will be ready for installation as construction of the house proceeds.
SUPPORTED BY Hawaii State Government

2.0014,
HEATING OF RURAL STRUCTURES WITH WIND-DERIVED ENERGY
L.H. Soderholm, Iowa State University of Science & Technology, U.S. Dept. of Agriculture Soil & Water Res. Conserv. Div., Agricultural Engineering Research, *Beardshear Hall, Agronomy Bldg. Room 225, Ames, Iowa* 50010 (3408-20690-002)
OBJECTIVE: Development of heating systems for rural structures using wind energy to reduce consumption of nonrenewable energy resources for heating, to provide standby heating in case of failure of other heating sources, assist in reducing electrical peak demand, and provide load leveling for heating systems using electricity as an energy source.
APPROACH: Install wind generating systems, controls, and heat storage for supplementary heating of farm structures in combination with heat pumps or other primary energy sources. Determine both theoretical and derived power from experimental wind systems and optimize wind system and storage concepts to obtain maximum heating systems efficiency and costs effectiveness.
PROGRESS: The Grumman wind system was out of operation from 12/77 to 9/78 because of mechanical problems that required return to the manufacturer for rework. A new replacement unit was received 9/78 and reinstalled. The new wind system had a number of operational problems that prevented satisfactory operation and required rework to overcome the design changes made by Grumman. Wind data and simulation of operational characteristics indicate that a properly performing unit could provide a substantial portion of the heating load of rural structures and make substantial contributions to load leveling on rural electric power systems.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Great Plains Area

2.0015,

WIND ENERGY FOR PUMPING IRRIGATION WATER

L.J. Hagen, Kansas State University, U.S. Dept. of Agriculture Agricultural Research, Wind Erosion Research Unit, *Dickens Hall, Room 205, Manhattan, Kansas* 66504 (3707-20740-001)

OBJECTIVE: Determine the seasonal wind energy distribution in the Great Plains and develop strategies to utilize wind energy for pumping irrigation water.

APPROACH: Analyze climatological data to determine seasonal wind energy distribution over the Great Plains. Develop a computer simulation model to explore strategies to satisfy irrigated crop water requirements using wind energy considering several energy storage possibilities and using realistic constraints on irrigation wells, pumps, and wind turbines.

PROGRESS: Wind-powered irrigation pumps using auxiliary power sources could supply 30 to 45% of the sprinkler energy demand and 60 to 70% of the energy demand of surface distribution systems. These results were obtained from a simulation study of various modes of operation of wind-powered irrigation pumps. A procedure was developed to match a wind turbine and pump for operation at variable speeds. Tests showed pump efficiency of 60% or more could be achieved over much of the speed range of the wind turbine.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Great Plains Area

2.0016,

ASSESSMENT OF INCENTIVES TO WIND ENERGY CONVERSION SYSTEMS

M. Lotker, Booz Allen & Hamilton Inc., *4330 East West Hwy., Bethesda, Maryland* 20014 (EG-77-C-01-4053)

The objective of the project is to identify the most effective forms of government economic incentives to commercialize large and small wind systems in various applications. Additionally, the project is to identify the cost and effects of the incentives and describe how the incentives could be implemented and timed. WECS technology implementation scenarios are being defined and diagrammed. After an assessment of barriers to WECS implementation, government incentives, which can mitigate these barriers, are to be identified and analyzed. The costs, effects, benefits, and problems associated with these incentives are also to be defined. In addition, criteria for selecting appropriate incentives are to be developed. (DOE/ET-0023/1)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0017,

FLUID MECHANICS PROBLEMS RELATED TO BIOLOGICAL FLOW PHENOMENA

S. Corrsin, Johns Hopkins University, School of Engineering, Dept. of Mechanics & Materials Science, *34th & Charles Sts., Baltimore, Maryland* 21218 (ENG77-25015)

Research will be carried out in the following areas of biologically related fluid mechanics: 1) Non-linear continuum mechanics of fluid flow through porous media, especially the application to include convective acceleration and mass transfer effects in the modeling of maternal blood flow in the placenta. 2) Mechanisms of sound generation during breathing, especially under pathological conditions which lead to relatively pure tones (wheezes), and those which lead to crackling sounds (rales). 3) Natural flight, especially shear and dynamic soaring of birds and fluctuating forces and motion of insect wings. These studies can lead to the understanding of more efficient ways of energy extraction from wind and a better understanding of unsteady aerodynamics.

SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science

2.0018,

DEVELOPMENT OF WIND POWERED EQUIPMENT FOR AGRICULTURE

L.A. Liljedahl, U.S. Dept. of Agriculture, Agricultural Research, Agricultural Environmental Quality Inst., Physical Control Lab., *Bldg. 303, Beltsville, Maryland* 20705 (1109-20400-001)

OBJECTIVE: Develop economic equipment to utilize wind power to cool milk and heat water on a dairy farm.

APPROACH: A windmill will be designed and built to provide power to several requirements at a dairy farm. Tests will be conducted to determine its suitability for this application, the operating characteristics of the system, local wind characteristics, and accuracy of design assumptions. Modifications will be made to improve performance or reduce cost as needed.

PROGRESS: Analysis of the vibrational modes of a 60-foot freestanding communication tower indicated that its modes are well separated from driving frequencies produced by either a 2- or 3-bladed, 32-foot diameter wind turbine. Further analysis showed that best load matching of a wind turbine driving refrigeration equipment could be achieved with two compressors having capacities in the ratio of the square root of three, driven with variable speed drive units. A friction loss analysis showed maximum friction loss would not exceed about 35%, which would occur at cut-in wind speed.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Beltsville Agricultural Research Center

2.0019,

WIND FORECASTING - WIND TURBINE OPERATIONS

D.B. Gilhousen, U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin., National Weather Service, Systems Development Office, Techniques Development Laboratory, *8060 13th St., Silver Spring, Maryland* 20910 (RC2903)

OBJECTIVE: To develop and evaluate automated forecasts of wind speed and direction for nine wind turbine generator (WTG) sites. In addition to these deterministic forecasts, probability forecasts of certain critical wind speeds will be developed.

APPROACH: The general method of approach to be used is Model Output Statistics (MOS). Single station equations will be derived from a record of numerical model output for projections up to 30 hours. An inflation transformation shall be used to enhance the speed forecast variability to approximate the observed speed variability.

PROGRESS: The data for the nine WTG sites have been successfully converted to a format needed by our statistical programs. Several trial regressions were performed. The critical wind speeds for which probability forecasts will be produced were determined after obtaining the range of observed wind speeds.

SUPPORTED BY U.S. Dept. of Energy

2.0020,

A MARKET ANALYSIS OF THE POTENTIAL FOR WIND SYSTEMS USE IN REMOTE AND ISOLATED AREA APPLICATIONS

J. Edwards, Energy Resources Co. Inc., *185 Alewife Brook Pkwy., Cambridge, Massachusetts* 02138 (EG-77-C-01-4051)

The project objective is to define, study, and estimate the size of markets for small and large wind systems in remote and isolated areas of the U.S. and Canada, their contiguous islands, and the West Indies. In addition, this project is to provide private industry with a collection of facts to serve as a basis for determining the market potential for commercial wind systems in these areas and provide strategies for developing these markets. Categories for wind system applications for isolated and remote area applications are being developed. Applications are to be further categorized according to average wind speed requirements. The base current market potential for each regional category is then to be estimated and adjusted by considering external controlling factors (i.e., fuel costs and energy demand, etc.) and user characteristics and requirements. For each regional category, a potential marketing strategy for use in possible marketing efforts by private industry is to be developed. (DOE/ET-0023/1)

SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0021,

WOOD COMPONENTS FOR WIND ENERGY SYSTEMS

R.B. Hoadley, University of Massachusetts, Amherst Campus, Agricultural Experiment Station, McIntire Stennis Program, *Amherst, Massachusetts* 01002 (MAS00023)

OBJECTIVE: Develop construction details and fabrication procedures for machine blades in wind energy systems. Develop use of wood support tower structural systems for wind power generators.

APPROACH: Engineering requirements of stress capabilities and weight distributuon to be determined by Civil Engineering Department. Wood technologists to select wood species and develop fabrication procedures. Civil Engineers will test wood propeller blades on wind power electricity generators.

PROGRESS: The first phase of the project has been completed as planned. Fabrication details were completed for an 8.2 ft. wind turbine blade having linear taper, linear twist and airfoil cross-sectional shape. The structural design incorporates a leading edge spar of laminated spruce, molded plywood upper and lower skins of sugar maple, and urethane foam filling. The surface has a protective coating of fiberglass reinforced epoxy resin. All fabrication and assembly can be accomplished with materials, equipment and methods familiar to many woodworking trades such as the boat building trade. It is estimated tht this blade will be favorably competitive in cost, weight and aerodynamic performance than the commercially produced blades currently available. Fixtures for preparation of components were built and a prototype blade was fabricated. Under static flexure tests the blade carried triple the maximum estimated wind loading without damage, indicating a probable safe overdesign. Work has begun on a set of operational blades with anticipated completion within the next report period. The blades will be tested on a 6 Kw Elektro generator.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Massachusetts

2.0022,

CLIMATOLOGY OF MICHIGAN

D.E. Linvill, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL03070)

OBJECTIVE: Provide climatological data for understanding the influence of the Great Lakes on Michigan climate; documentation, reports, etc., used in the research and management decision process; evaluation of advertent and inadvertent weather midification activities; land use planning; crop feasibility studies; development of a computerized data source to provide adequate desing criteria for hydrological designs, erosion control, waste water management, etc.

APPROACH: Michigan climatological data will be put into a form allowing rapid computer access. Climatological summaries will be prepared from these data banks.

PROGRESS: Climatological data for the complete period of record at Adrian, Allegan, Alma, Bloomingdale, and East Lansing have been entered onto computer tape, cleaned and verified. We are continuing to add new stations to the tapes as time permits. Volunteer dense raingauge networks have been operating in several counties for the last 3 to 4 years. This data is being prepared to demonstrate macroscale precipitation variation within Michigan. Analysis of wind along Lake Michigan is underway. Hourly data from Coast Guard Stations at Ludington, Muskegon, Point Bessy and Grand Marias are available on computer tape. Dedicated sites at Hart, Michigan are being used to determine wind power potential along the lake.

SUPPORTED BY Michigan State Government

2.0023,

TECHNICAL AND ECONOMIC FEASIBILITY OF A SOLAR AND WIND ENERGY APPLICATION AT A MICHIGAN HIGHWAY REST AREA

H.R. Zapp, Michigan State University, School of Engineering, Dept. of Engineering Research, *Engineering Bldg., East Lansing, Michigan* 48824 (192846 (HRB NO.))

To study the feasibility of installing a hybrid solar/wind electrical generating system for a proposed rest area and information center along US-31 south of Niles, Michigan. The study is to be conducted in three phases: 1. Technical and economic feasibility; 2. design and implementation and 3. monitoring, data collection and demonstration. The system is to consist of an 800 sq. ft. photo-voltaic array and two wind turbine generators for a combined total peak capacity of 35 KW.

SUPPORTED BY Michigan State Government

2.0024,
CHARACTERIZATION OF CLIMATE & ASSESSMENT OF IMPACT ON AGRICULTURE & OTHER RENEWABLE RESOURCES
D.G. Baker, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Soil Science, *St. Paul, Minnesota* 55101 (MIN-25-064)
OBJECTIVE: Characterize the time and space distribution of climatic parameters that relate to agr. production; extend and improve the climatic and environmental data base; organize project results and information into forms readily available to users; implement the research aspects of the National Climate Program that pertain to agriculture and renewable resources.
APPROACH: Climate variables will include solar radiation, ppc, soil moisture and soil temp. Time distribution to evaluate estremes and probability values for weekly and monthly periods will be determined and their impact upon agricultural production will be assessed through the use of models. A network for improved observations will be expanded to provide one station at the intersection of every 4 townships for ppc, 20-30- stations for seedling depth temperatures and approx. 50 sites across Minn. for soil moisture. Models will be developed for such application as irrigation scheduling, and crop development estimates. User oriented forms will include summarized data and distributed through the Coop. Ext. Serv. and other State and Federal agencies. The above relates to the objectives of the National Climate Program.
PROGRESS: The 16 year (1963-1978) solar radiation record at St. Paul continues to be analyzed in great detail. Several publications have resulted and the most recent manuscript completed deals with the probability of runs of days during each month in which the total radiation fails to exceed a given value. Similarly the probabilities have been determined for runs of days in which the total radiation never falls below given values. With the completion of that study two other energy related studies have been initiated. One deals with solar radiation and the other with wind climatology. In the former we are concerned with the distribution of hourly radiation values during each hour of the solar day. This study is based upon the hourly values of solar radiation during each day in 8 different weeks over a 7-year period. The wind energy study is combination of a wind climatology and the statistics of wind energy at 8 different stations. Information being gathered includes the monthly frequency of occurrence of various wind speed classes, probability of occurrence of the various wind speed classes, percent of time wind speed is greater than a particular speed, mean wind speed. (Text Truncated - Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Minnesota

2.0025,
UTILIZATION OF THE CLIMATIC RESOURCE
W.L. Decker, University of Missouri, Columbia Campus, Agricultural Experiment Station, Dept. of Atmospheric Science, *130 Jesse Hall, Columbia, Missouri* 65201 (MO-00311)
OBJECTIVE: Examine the energy use of crop canopies in terms of photosynthetic and water efficiencies, develop workable mathematical expressions for predicting yield of important crops from weather data, describe the climate of the state in terms of probability of climatic events favorable for Missouri's agriculture.
APPROACH: The effect of canopy design on utilization of sunlight and evapotranspiration by soybeans will be studied along with the influence of atmospheric conditions. The prediction of yields for soybeans and other Missouri crops will be attempted from statistical models. Existing regression methods will be refined to increase their precision. An analysis of availability of solar energy and atmospheric radiation will be completed. Wind power as a resource will also be examined. Additional analyses to isolate management strategies most suitable to Missouri's climate will be made.
PROGRESS: Soybean responses to the environment imposed by atmospheric and soil properties have been studied. A statistical model for predicting yields in soybeans from readily available weather data has been developed. Through this analysis an iterative regression technique has been tested. The stress to which soybeans are placed by atmospheric conditions and soil moisture deficiencies has been examined for several alternate farm management systems. Row spacing and methods of tillage have little effect on moisture stress in soybeans while date of planting produces significant differences. The amount of evapotranspiration from soybeans has been examined. The greatest water utilization occurs during the period from 20 days after emergence to 20 days after initial flowering, and during this period the daily evapotranspiration ranges from 4 and 6.5 mm. A probability analysis of the Palmer Drought Index and the Crop Moisture Index was completed. The probability of drought of a given intensity was independent of geographic region and season, while the probability of given values of the Crop Moisture Index was highly dependent on location and time of the year.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Missouri

2.0026,
VERTICAL AXIS WIND TURBINE
R.C. Maydew, Sandia Lab., *P.O. Box 5800, Albuquerque, New Mexico* 87115 (00004011)
The VAWT project will demonstrate that wind power is economically competitive with other sources of power. It will be shown that the VAWT can be fabricated more economically than conventional horizontal axis wind turbines. The VAWT will be applicable to small generators for use in remote areas and also large generators for commercial power production. The project includes: (1) parametric optimization of aerodynamics and economics of blade and starter; (2) system study of wind environments to maximize power; (3) wind tunnel tests; (4) prototype systems demonstrations for self-contained, small (5 to 30 kW) farm systems and large (100 kW to 1 MW) electrical grid systems; and (5) systems application to geographically remote areas such as the Marshall Islands.
SUPPORTED BY U.S. Dept. of Energy

2.0027,
ECONOMIC ANALYSIS OF WIND ENERGY FOR IRRIGATION PUMPING
R.R. Lansford, Southwest Research & Development Co., *1825 Imperial Ridge, Las Cruces, New Mexico* 88001 (7011-20740-006-C)
OBJECTIVE: Assess the economic feasibility of utilizing wind power as a source of energy for pumping irrigation water by providing estimates of: Number or irrigation pumping plants used in the United States; the investment in wind power system which would break even with present power sources and cost; and the number of potential wind powered irrigation pumping plants by region for alternative prices of present energy.
APPROACH: Irrigation pumping installations will be grouped by size, water source, and present energy sources for each area having similar average windspeeds. The annual costs of energy with present energy sources will be calculated for pumping operations of different size and average annuals hours of operation using different levels of energy prices. The investment in wind power systems which will break even with the present power sources will be calculated for pumping operations of different size and average annual hours of operation using different levels of energy process. The investment in wind power systems which will break even with the present power sources will be estimated for each level of energy costs used and by wind power regions and irrigation load categories. From the data, the number of potential wind powered irrigation pumping plants by region will be estimated for alternative prices of present energy sources.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Oklahoma - Texas Area

2.0028,
ENERGY CLIMATE OF NEW YORK STATE
B.E. Dethier, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agronomy, *Ithaca, New York* 14850 (NYC-125434)
OBJECTIVE: Describe and quantify the energy climate of New York State. Establish a data base for future interdisciplinary studies at the Center.
APPROACH: Solar radiation and wind direction and velocity at 10 meters will be observed and recorded at several sites (Harford, Ithaca, Mt. Pleasant, Aurora, Canton, Chazy and Valatie). These data will be used with data from other stations (Geneva, New York City, etc.) to obtain probability of occurrence of events meaningful to agriculture and other energy related activities. This information will be useful in characterizing energy consumption and in assessing the potential for extracting energy from wind for utilizing solar energy. Final results will be presented in map and tabular form for presentation in suitable station publications. The data will also be included in the monthly weather summaries currently published by the unit.
PROGRESS: New radiation sensors were acquired and an electronic integrator was developed and is being tested. The new sensors will be included in the existing station network and at least one will be included in an automatic data logger suitable for remote interrogation by computer.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New York

2.0029,
WIND ENERGY SUBSTITUTION AT DAIRY MILKING CENTER
W.W. Gunkel, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123335)
OBJECTIVE: Construct a wind turbine at the Cornell Dairy Research Farm using a commercially available unit. Design and construct a system to provide direct water heating through churning action in an enclosed container. Collect wind speed data at the site. Collect data to measure the effectiveness of the wind turbine conversion system.
APPROACH: The researchers will cooperate with a commercial wind turbine manufacturer to erect a wind turbine with blade or propeller diameter of approximately 32 feet. Engineering analysis will be conducted to design the blades to be used in the liquid churn to match the output of the wind turbine for optimum operation. The churn will be constructed and a full scale pilot demonstration system will be developed and tested.
PROGRESS: More sophisticted wind instruments have been installed at the wind turbine site located at the Cornell Teaching and Research Center and continous wind data obtained. Laboratory tests of the fluid friction heating device have been completed and design equations developed to permit the most efficient matching between wind turbine and fluid friction heating device. A three-bladed vertical axis wind turbine has been installed and a wind laboratory constructed around the tower base located at the Cornell Teaching and Research Center. Performance testing of the commercial wind turbine is presently being conducted. A system study of hot water requirements in a typical dairy operation as well as heat requirements for residential space heating and domestic hot water has been completed. The information from this study together with equipment costs and available wind energy is being used to develop an optimal design of direct wind energy water heating systems.
SUPPORTED BY New York State Government

2.0030,
ENVIRONMENTAL STUDIES RELATED TO THE OPERATION OF WIND ENERGY CONVERSION SYSTEMS
S.E. Rogers, Battelle Memorial Inst., Columbus Laboratories, *505 King Ave., Columbus, Ohio* 43201 (W-7405-ENG-92)
The general objective is to address the social and environmental impacts of the widespread use of wind systems. The specific objective is to establish the potential for secondary effects on the microclimate, biota, and airborne organisms, particularly birds, created by blade rotation of wind energy conversion systems to determine the compatibility of wind turbines with agricultural use. Large two-bladed, horizontal-axis wind turbine generators (WTG) were studied using the NASA Experimental Wind Turbine at NASA Lewis Research Center's Plum Brook Station as the model for field tests. The biophysical environment was the focus of the study.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0031,
COMPUTER SIMULATION OF ENERGY STORAGE SYSTEMS FOR SOLAR APPLICATIONS
W.J. Masica, U.S. National Aeronautics & Space Admin., Office of Aeronautics & Space Technology, Lewis Research Center, *21000 Brookpark Rd., Cleveland, Ohio* 44135 (776-71-41)
The objective of this effort is the development of an analytical model and computer program for general use in designing and analyzing the cost/performance of energy storage systems for solar (wind, photovoltaic) applications. Emphasis will be given to mechanical (flywheels, hydro, compressed air), chemical (hydrogen), electrical (battery), and thermal (sensible/latent) energy storage systems. Current specific effort will be devoted to transient analysis modeling

for the previously developed (FY 76-77) Simulation Model for Wind Energy Storage. This project has a subcontract to Boeing Computer Services Co.
SUPPORTED BY U.S. Dept. of Energy

2.0032,
WIND ENERGY
H.J. Allison, Oklahoma State University, Agricultural Experiment Station, Dept. of Electrical Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075
A process for producing ammonia was developed by Lockheed during this study. The process uses nitrogen from the atmosphere and hydrogen from an electrolysis cells powered by electricity derived from a large windmill.
SUPPORTED BY Lockheed Aircraft Corp.

2.0033,
STABILITY STUDIES
R.G. Ramakumar, Oklahoma State University, Agricultural Experiment Station, Dept. of Electrical Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075
Transient behavior of wind-driven synchronous machines feeding power into a utility grid was studied under gusting wind conditions. Influence of the coupling in the mechanical interface was critically examined from the electrical stability, energy collection, and energy delivery viewpoints.
SUPPORTED BY Oklahoma State Government

2.0034,
CAPACITY CREDIT AND RELIABILITY STUDIES
R.G. Ramakumar, Oklahoma State University, Agricultural Experiment Station, Dept. of Electrical Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075
Simulation studies are being carried out to investigate the reliability and capacity credit aspects of wind-electric conversion systems operating in parallel with existing utility grids. Influence of different penetrations, wind regimes, and load models will be examined.
SUPPORTED BY Oklahoma State Government

2.0035,
DEVELOPMENT AND USE OF WIND ENERGY AND ANALYSIS OF AERODYNAMIC WIND TURBINES
R.W. Thrasher, Oregon State Higher Education System, Oregon State University, School of Engineering, Dept. of Mech Engin, *200 Covell Hall, Corvallis, Oregon* 97331
An analysis of the aerodynamic characteristics of wind turbines and their potential in the development and use of wind energy.
SUPPORTED BY U.S. Dept. of Energy

2.0036,
CLIMATIC RESOURCES OF THE NORTH CENTRAL REGION
W.F. Lytle, South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Brookings, South Dakota* 57006 (SD00565)
OBJECTIVE: Define Mathematical models for assessing the potential effects of Weather Modification in specific areas of the North Central Region. Delineate by graphs, maps, and tables the climatic variation in windy pan evaporation, evapotranspiration, soil temperature, and cumulus clouds in the North Central Region and compute parameters that will describe probabilities of these data.
APPROACH: By step-wise multiple regression techniques find the relationship between crop yield, quality, and various climatic variables. This type of research was started on a project started for the Bureau of Reclamation and should be further refined and different climate variables explored that were not used before. Use all the possible models of rainfall increase suggested by researchers in Weather Modification experiments to predict from historical rainfall all the possible amounts of rainfall increase that could occur in the various climatic parts of the region. Continue a pilot study analysis of wind data that would be helpful to determination of energy potential available throughout the North Central Region. Analyze the pan-evaporation data available in terms of the climatic variables that effect the readings and determine relationship to evapotranspiration data.
PROGRESS: Obtained magnetic tapes of all hourly wind data collected at Aberdeen, Huron, Rapid City and Sioux Falls. Continued work on wind analysis procedure for NC-94 proposed project on wind energy probabilities in the 13 North Central States. Time spent at NC-94 meeting and at Brookings in revising Project Statement since it runs out in September 1979. Work continued with Electrical Engineering Department in developing a micro-processer that will give hourly averages of wind velocity and wind energy available at Brookings, South Dakota.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, South Dakota

2.0037,
WIND ENERGY FOR AGRICULTURAL APPLICATIONS
L.R. Verma, South Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Brookings, South Dakota* 57006 (SD00796)
OBJECTIVE: Calculate the wind energy available at selected sites in SD. Study the intensity and variation in this energy on a daily and monthly basis. Study the relative potential of wind energy as compared to other alternate energy sources. Evaluate the combined potential of wind and solar energies at selected sites in South Dakota. Investigate the potential of wind energy for agricultural applications.
APPROACH: The main thrust will be toward the feasibility of wind energy use for agricultural application, such as, crop drying, grain drying, and space heating. Existing climatological data at various locations in SD. will be evaluated for wind energy potential; including wind variation studies. Some specific analysis will be made on the availability of wind power from data. The total wind energy flux passing unit area for each month of the year, average daily wind energy flux, the distribution in time of the available wind energy, number of hours per month with wind speeds adequate for effective wind energy conversion, details about the incidence and duration of calm periods. Results obtained to be used in combination with available solar energy information to evaluate the combined potential of wind and solar energies in SD.
PROGRESS: Wind data have been analyzed for Huron, South Dakota with respect to the potential energy available and energy density. Power duration curves were developed based on the wind data. Relationships were developed over a variety of time spans, daily, weekly and monthly. Graphical coorelations were derived to indicate the energy density available for wind energy, solar energy and the combined wind and solar energies. Indications are that for the Eastern South Dakota area a significant potential increase in energy density may be achieved through the combined use of solar and wind energy. An extensive literature search was initiated to determine the state of the art in wind energy technology and its potential adaptability to selected agricultural application. Particular emphasis was placed on reviewing literature on vertical axis wind turbines. Also, a tour was taken of the wind energy research installation at Rocky Flats, Colorado.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, South Dakota

2.0038,
STUDY OF EFFECT OF WIND GENERATION ON OPERATION OF POWER SYSTEM
T.R. Walker, U.S. Tennessee Valley Authority, *401 Chestnut St., Room 268 - 248 401 Bldg., Chattanooga, Tennessee* 37401 (TVA 988-15-990.6052)
Under an interagency agreement with the Department of Energy, prepare a description of fundamentals of the operation of an electric power system, including TVA's, and develop and implement a 2 to 3 day operating plan. Compare actual dispatch with planned dispatch. Configure the TVA power system to include assumed wind generation for later use by DOE in simulation studies to determine the effect of wind generation on the operation process. Energy Research will provide project management and cooperate with the Divisions of Power System Operations in documenting the operation of the power system and with the Division of Transmission Planning and Engineering and the Division of Power Resource Planning in developing a system that would include assumed wind generation.
SUPPORTED BY U.S. Tennessee Valley Authority

2.0039,
UTILIZATION OF WIND ENERGY FOR PUMPING IRRIGATION WATER FROM WELLS
A.D. Schneider, U.S. Dept. of Agriculture, Agricultural Research, Conservation & Production Research, *Bushland, Texas* 79012 (7315-20741-002)
OBJECTIVE: Evaluate the performance of a wind rotor for driving an irrigation pump; develop irrigation pumping equipment that can be effectively driven by a wind rotor; determine economic feasibility of wind powered irrigation pumping systems; develop a computer model of a vertical axis wind rotor.
APPROACH: A wind rotor will be installed near an existing water well. The wind power into the rotor and the power delivered to the pump will be measured to determine efficiency. Commercially available pumps will be modified as necessary to attach them to the unsteady power input. Four types of pumps will be evaluated--air lift, turbine, positive displacement piston, and positive displacement rotary. Cost comparisons will be made with pumping an equal amount of water by present energy sources. A computer model of a vertical axis wind rotor will be developed so that the performance of the wind machine can be simulated over long-time periods and with different wind regimes.
PROGRESS: A wind-assisted irrigation pumping system was constructed and tested using a 40 kW vertical-axis wind turbine and a conventional irrigation pump. The pumping system uses both a wind turbine and an electric motor to power the conventional vertical deep-well irrigation pump. The electric motor is sized to operate the pump on a stand-alone basis and runs continuously. The wind turbine is coupled to the pumping system through an overrunning clutch and furnishes power to the pump only when windspeed exceeds 6 m/s. When the wind turbine operates, the electric motor is not being replaced, but the electric load is being reduced. The vertical-axis, or Darrieus, wind turbine was designed to produce 40 kW in a 15 m/s wind and has a rotor height of 17 m and a maximum rotor diameter of 11.3 m. The mechanical drive between the wind turbine and the irrigation pump contains a right angle speed increaser, a timing belt speed increaser, a disk brake, and an overrunning clutch. The wind turbine shaft speed is increased from 90 to 1790 rpm to drive the pump. The irrigation well produces 100 m 3/hr, and the total dynamic head is 105 m. The vertical-axis wind turbine begins producing power at 6 m/s and the power output continues to increase until the turbine is stopped at 20 m/s. At Bushland, TX, 90% of the available power in the wind occurs within this windspeed range. (Text Truncated - Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Oklahoma - Texas Area

2.0040,
DEVELOPMENT OF A 1 KW HIGH RELIABILITY WIND TURBINE GENERATOR--2 BLADED DOWNWIND
B. Drake, Enertech, *Norwich, Vermont* 05055 (E(29-2)-3533)
An increasing number of applications for very small wind systems involve rural and remote needs for powering repeater stations, seismic monitoring stations, and offshore navigation aids, as well as for pumping water into remote stock watering tanks. An economical, rugged wind turbine with an output of 1 kW has been identified as ideal for such applications. The project objective is to challenge industry to develop the technology needed to produce such a system at a retail cost of about $1500 per installed kW ($77). Three contractors will be selected from among respondents to an FY 1977 RFP to design, fabricate, and test such systems. This will be followed by the procurement of a sufficient number of pre-production units to determine firm cost data. This project is a subcontract. (DOE/ET-0023/1)
SUPPORTED BY Rockwell International Corp.

2.0041,
DEVELOPMENT OF A 1 KW HIGH RELIABILITY WIND TURBINE GENERATOR--3 BLADED UPWIND
D. Mayer, North Wind Power Co., *Warren, Vermont* 05674 (E(29-2)-3533)
An increasing number of applications for very small wind systems involve rural and remote needs for powering repeater stations, seismic monitoring stations, and offshore navigation aids, as well as for pumping water into remote stock watering tanks. An economical, rugged wind turbine with an output of 1 kW has been identified as ideal for such applica-

tions. The project objective is to challenge industry to develop the technology needed to produce such a system at a retail cost of about $1500 per installed kW ($77). Three contractors will be selected from among respondents to an FY 77 RFP to design, fabricate, and test such systems. This will be followed by the procurement of a sufficient number of pre-production units to determine firm cost data. This project is a subcontract. (DOE/ET-0023/1)
SUPPORTED BY Rockwell International Corp.

2.0042,
SOLAR-WIND DESALTING (SOWIDE)
M. Garstang, Simpson Weather Associates, *Charlottesville, Virginia* 22903
SUPPORTED BY U.S. Dept. of Energy

2.0043,
ECONOMIC ANALYSIS OF WIND-POWERED CROP DRYING AND REFRIGERATION COOLING/WATER HEATING SYSTEMS
R.H. Forste, Tetra Tech Inc., *1911 N. Fort Meyer Dr., Suite 601, Arlington, Virginia* 22209 (1090-20401-005-C)
OBJECTIVE: Determine the economical potential for use of wind energy systems in crop drying and refrigeration cooling/water heating systems.
APPROACH: The study will be conducted by determining the number, size, and type of present operations; classify operations by category of present power source, power requirements, type of operation, season of operation, and geographical region; estimate costs of present energy source; determine suitability of wind power to satisfy the energy requirements of the operation; estimate the breakeven costs of wind-powered systems in $/kW for those that can be satified; and estimate the number of users vs breakeven cost of wind power for various operations.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Beltsville Agricultural Research Center

2.0044,
APPLICATION OF WINDMILLS TO APPLE COOLING AND STORAGE
D.H. Vaughan, Virginia Polytechnic Inst. & State University, School of Agricultural & Life Sciences, Dept. of Agricultural Engineering, *Blacksburg, Virginia* 24061 (VA-0331924-1)
OBJECTIVE: Field test an apple cooling and storage facility using a windmill to provide the energy required. Document windmill performance, total system performance, and wind and weather variations. Conduct economic and cost analyses of the tested windmill application to assess the utility and attractiveness of the system in light of the test resusts and projected advances in windmill technology.
APPROACH: Meteorological measurements, including windspeed, will be made in order to select a site which has 'good' wind energy availability. A state-of-the-art apple cooling facility (including building and refrigeration equipment) will be designed to be used as a test bed for the windmill application. The building will have energy conserving measures such as extra insulation. A commercially available windmill will be selected to match the cooling requirement and purchased. Two methods of thermal energy storage will be used. Batteries will be used to store the electrical energy generated by the windmill generator. Electrical energy from the batteries will power the refrigeration system, which will be used to make ice in a tank/thermal exchanger. The ice tank will be used for cooling purposes, especially during the high cooling load period when the apples are loaded into the building. The windmill application will be fully instrumented to recorded windmill parameters, weather, apple environment, and cooling system performance.
PROGRESS: A wind-powered refrigeration facility was evaluated during 1978 for cold storage of apples. The facility included a 10 kW wind turbine generator, nickel-cadnium storage batteries (13 kWh), a 1000-bushel cold storage building (14 m multiplied by 7 m multiplied by 3 m high), a 3 hp d.c. vapor-compression refrigeration system (Freon 12), and an ice tank thermal storage unit (285 kWh). Five varieties of apples were stored at 0 degrees C and 85% relative humidity beginning on September 7. The Electro WVG120G 3-bladed, high-speed propeller-type wind turbine, rated at 10 kW at 10.7 m/s wind speed, was mounted on a 27.4(3)m reinforced radio tower. The cooling system included a centrifugal circulating fam (2000 m 3/h flow rate) driven by a 0.19 kW d.c. motor, compressor and condenser unit (rated capacity of 6.5 kW at suction temperature of minus 1. (Text Truncated - Exceeds Capacity)
SUPPORTED BY Virginia State Government

2.0045,
MANAGEMENT SUPPORT FOR THE WIND CHARACTERISTICS PROGRAM ELEMENT
J.V. Ramsdell, Battelle Memorial Inst., Pacific Northwest Laboratories, *P.O. Box 999, Richland, Washington* 99352 (EY-76-C-06-1830)
Objectives include: (1) developing information on wind descriptors for designers and manufacturers, (2) determining and evaluating techniques for WECS siting, (3) assessing the wind resource on national and regional scales, and (4) liaison activities to distribute wind characteristics information. The role of models in WECS siting will be re-examined to identify the most cost-effective models for continued development. (ERDA-77-32)
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

2.0046,
EVALUATION OF A WIND ENERGY CONVERSION SYSTEM FOR AGRICULTURAL APPLICATION
C.F. Becker, University of Wyoming, Agricultural Experiment Station, Dept. of Agricultural Engineering, *University Station, Laramie, Wyoming* 82071 (WYO-148-078)
OBJECTIVE: Secure meterological data and correlate with performance of a wind energy conversion system (WECS) as related to agricultural farmstead electrical energy needs.
APPROACH: A computer direct digital data acquisition system to monitor wind speed and direction, other meteorological data, electrical consumption used for water heating, home use, feed grinding and other uses at the University of Wyoming Dairy Farm will be constructed to record the data on magnetic tape and display the information in real time for decison making and control. Information on energy received from and supplied to the utility energy grid will also be secured. Energy requirements for various applications and performance of the WECS will be correlated with meteorological parameters.
PROGRESS: Work on the Wind Energy Conversion project consisted primarily of construction, installation, and debugging of basic components. Support towers (13.5 m and 4.3 m) and data acquisition system are in place and the latter is monitoring several meteorological parameters and selected data from the generator which is installed on 4.3 m tower for testing and performance verification. Monitoring of the energy utilized by the UW Dairy milking complex will begin in the near future.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Wyoming

2.0047,
WIND-PUMP AND SOLAR STILL DEMONSTRATION
Unknown, Community & Cultural Affairs, *Saipan, Mariana Islands* 96550
SUPPORTED BY U.S. Dept. of Energy

2.0048,
PRE-SEA PROJECT
E.R. Andreatta, Universidade Federal de Santa Catarina, Centro de Ciencias Agrarias, *Caixa Postal No. 476, Florianopolis 88000, Brazil*
Funded by FINEPE and SUDEPE, the project in development at this University, is the culture of Mugil curema, in semi-elevated ponds.
The first phase of the project consist in 5 ha. of ponds, where water is supplied by tides, pumps (electric and wind-powered) and is individually drained by a gravitational system. The initial population is being composed with alevines captured in the estuary. Investigations of induced spawning will be done.
The research looks for detailed information of the weight gaining time, the possibilities of reproduction, and the operational cost of the proposed handling. Different nutritional treatments will be used, like plankton obtainment by water fertilization with organic, chemical or organic-chemical products. Enriched wheat may be used as additional support.
Once the results of the research shows economical and technological practicability, some of the 150,000 ha. (62,500 acres) of mangrove in the shores of Santa Catarina State may be explored by the local fisherman and industries, offering economical profits for the local population, without damaging that important ecosystem.
The first rates will be obtained in two years, after the conclusion of the project.
Ecological parameters for terrestrial studies: Latitude, 27-30 degrees S.; Altitude, 1 meter; Soil types, mangrove; Mean annual temperature, 20 degrees C; Months of greatest moisture, all year; Growing season, 365 days; Mean annual rainfall, 1400 mm; Mean annual humidity, 84 percent; Number of wet seasons, all year.
Ecological parameters for aquatic studies: Latitude, 27-30 degrees; Water salinity, 8.2 percent; Water temperature, 20 degrees C; Water pH, 7.2.
SUPPORTED BY Financiadora de Estudos e Projectos

3. GEOTHERMAL ENERGY

3.0001,
VEGETABLE IMPROVEMENT FOR INTERIOR ALASKA
D.H. Dinkel, University of Alaska, Fairbanks Campus, School of Agriculture & Land Resource Management, Dept. of Horticulture, *Fairbanks, Alaska* 99701 (ALK44418)
OBJECTIVE: Evaluate and select new vegetable cultivars for Interior Alaska for home garden, greenhouse, commercial and processing use. Develop improved nutrition and cultures for new and standard cultivars. Evaluate the climatic and soil factors on growth of vegetables in the greenhouse and outdoor culture.
APPROACH: Vegetable cultivars from the many breeding programs thoughout the world, especially from similar northern latitudes will be evaluated and compared using the best known cultural practices. The soil temperature, soil moisture and long cool sunlight environment will be studied in relationship to vegetable growth, yield, and quality and to nutritional requirements. Major attention should be given to devising techniques to utilize the vast quantities of geothemal and waste heat energy for the production of vegetable crops in greenhouse, outdoor soil heated areas and for processing.
PROGRESS: Cool-season vegetable crops were planted April 17 on soil heated by cooling water from a coal-fired power generation plant. Cabbage, broccoli, cauliflower, spinach, lettuce, beets, and green onions were harvested by July 10; and a second crop planted in this area and completely harvested before freezeup. This demonstrated the potential for two successive crops of cool-season vegetables on soil that could be warmed and the season extended utilizing reject heat. Total yield growth rates of all crops except lettuce were greatly increased where the soil was warmed. A simulated waste heat system was used to heat greenhouse soils and extend the normal production season for tomatoes and cucumbers demonstrating that a longer harvest season and greater yield could be achieved where economical heat sources were available. 'Green Duke', 'Regal', 'Green Umbrella', 'Green Dwarf', and 'Gem' broccoli yielded more than 1.3 kg/m. 'Tastie', 'Hybrid 15', 'Greyhound', 'Tokyo Pride', and 'Erin' were the best adapted cabbage cultivars for the interior. 'Minilake' and 'Ithaca' lettuce; 'Snow Crown', 'Super Snowball', 'Dominant', and 'Christmas White' cauliflower; 'Saladin' and 'Early Surecrop' cucumbers; and 'Onthyb 742', 'Mordan 71112', 'Earliking' and 'Earlivee' sweet corn were outstanding cultivars. 'Boston Marrow' squash yielded 17 kg/m when grown through clear polyethylene. Row covers consisting of two sheets of 3.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Alaska

3.0002,
USE OF THERMAL EFFLUENT IN THE CULTURE OF CRUSTACEA
J. Van Olst, California State University & Colleges, San Diego State University, School of Sciences, Dept. of Biology, *5402 College Ave., San Diego, California* 92115 (R/A-21)
OBJECTIVES: The objective of this program is to assess the benefits and problems involved in using thermal effluent from coastal power stations as an economical source of heat in the culture of marine species of commercial importance in southern California and to develop the biological and technical information necessary for their successful culture. Research will continue on certain specific aspects of

the culture of the Amencan lobster, Homarus americanus, which are crucial to the successful culture of this species.
ANTICIPATED BENEFITS: Seafood dealers and processors who are members of the UCSG Seafood Advisory Panel have stressed the importance of research on aquaculture. These industries are now adversely affected by overexploitation of most of California's marine resources and will benefit directly from commercial cultivation in the future. The electric utilities industry will benefit from this research, especially if cooling water temperatures could be reduced even slightly through use of thermal effluent in aquaculture. Even if this goal is not achieved, successful aquaculture at generating stations may be interpreted as a positive means of compensating for any adverse environmental effects associated with the effluent. Finally, the emerging aquaculture industry in the U.S., and particularly in California, stands to benefit directly from this research.
IDENTIFIED BENEFITS TO DATE: Several aquaculture firms are making direct use of this project's results in their enterprises. Various communities consulted the researchers about possible utilization of geothermal springs in aquaculture. San Diego Gas and Electric company and Southern California Edison have been actively involved with this research, which has enhanced the public's awareness of the utility industry's interest in mitigating adverse environmental effects of thermal effluent. Through tours of the aquaculture project, the general public and pre-college students have gained a greater understanding of aquaculture, thermal effluent, and power plants.
SUPPORTED BY U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin., Sea Grant Office

3.0003,
DEMONSTRATION OF THE APPLICATION OF GEOTHERMAL ENERGY IN THE KELLEY HOT SPRINGS AGRICULTURAL CENTER
A.B. Longyear, Geothermal Power Corp., *P.O. Box 1186, Novato, California* 94947 (AC03-79ET27041)
The project objective is to design an integrated swine raising complex and a geothermal direct energy system to serve this complex. The approach is the engineering design and economic analysis of building a complex which may include an environmentally controlled growing systems building, feed mill, swine raising complex and maintenance support building, through adaption of commercial designs and equipment, to the economic utilization of geothermal heat for heating, cooling, waste handling, and other economic means of by-product processing.
SUPPORTED BY U.S. Dept. of Energy, Office of Resource Applications, Office of Industrial & Utility Appl. & Oper., Div. of Geothermal Energy

3.0004,
GEOTHERMAL ENERGY FOR SUGAR BEET PROCESSING
J.J. Seidman, Thompson Ramo Wooldridge Inc., Energy Systems Management Division, *1 Space Park, Redondo Beach, California* 90278 (97248)
The project objectives are to design, build, operate and evaluate the geothermal processing facility for sugar beets. The approach is to exploit the existing resource to develop geothermal energy for direct generation of steam and heat to be used in processing sugar beets and pulp. It is planned that geothermal energy will replace most of current fossil fuel in a commercial installation.
SUPPORTED BY U.S. Dept. of Energy, San Francisco Operations Office

3.0005,
THE COMMERCIAL APPLICATION OF GEOTHERMAL RESOURCES IN THE FOOD INDUSTRY IN THE WESTERN STATES
W.M. Hanemann, University of California, Berkeley Campus, Agricultural Experiment Station, Dept. of Agricultural & Resource Economics, *Berkeley, California* 94720 (CA-B#-AEC-3869)
OBJECTIVE: Evaluate the economic, financial and engineering obstacles to the commercial application of hydrothermal geothermal resources in the food industry in the Western states. Special emphasis will be placed on market tactics within the industry and on involving industry leaders in a cooperative investigation of the potential scope for geothermal energy in their industry.
APPROACH: Working in close liaison with firms in the industry we will examine: Present and future trends in technology to determine compatibility with geothermal energy and the need for appropriate process change, and industry economics and present and future trends in market sturcture and plant location in relation to the supply of geothermal resources. The initial focus will be the fruits and vegetables processing sector, to be followed later by other sectors of the industry.
SUPPORTED BY California State Government

3.0006,
IMPROVED GREENHOUSE PRODUCTION SYSTEMS
H.C. Kohl, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Environmental Horticulture, *Davis, California* 95616 (CA-D#-EHT-3334-H)
OBJECTIVE: Devise a greenhouse system oriented to the use of geothermal energy and thermal polluting water, coolant from nuclear power generating reactors and to the special problems of arid climates. Devise greenhouse production systems oriented to the needs of the amateur plant grower.
APPROACH: Index cultivars of ornamental plants according to maximum, minimum and optimum temperature requirements in order to provide information for development of energy conserving modifications of current greenhouse growing systems. Devise and test crop production systems which utilize multiple layers of plants (particularly at night) to make most efficient use of heated space. Devise a greenhouse system oriented to the use of geothermal energy and thermal polluting water, nuclear power, generating reactors and to special problems of arid climates. Devise greenhouse production systems onented to the needs of the amateur plant grower.
PROGRESS: Simulation model for productivity of chrysanthemum pot plants has been revised on basis of experimental data. Publication indicates that productivity of plants growing at low night temperature is same as for plants growing at normal night temperature providing LAI is above the critical level. Kohl, Jr., H.C. and Thighen, S.P. 1979. Rate of dry weight gain of Chrysanthemum morifolium in Bright Golden Anne as a function of leaf area index and night temperature. Jour. Am. Soc. Hort. Sci. (accepted for publication). Work is started on increasing percentage dry weight in flowers and plants grown at low night temperature. Work is started on increasing leaf expansion rate on plants grown at low night temperatures.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

3.0007,
INTENSIVE CULTURE OF TILAPIA IN GEOTHERMAL WATERS IN THE SAN LUIS VALLEY, COLORADO
S. Flickinger, Colorado State University, School of Forestry & Natural Resources, Dept. of Fisheries & Wildlife Biology, *Fort Collins, Colorado* 80523 (COL00067)
OBJECTIVE: Develop techniques to spawn tilapia year-round and to have only males for rearing either through early sorting or through hybridization to produce all male offspring.
APPROACH: Brood fish will be held under various photopericds to determine what length induces spawning and what length inhibits spawning. With controlled spawning to produce large nimbers of offspring at the same time, grading to sort faster growing, and hence larger, males will be tried for accurcay in sorting sexes. Hybrid crosses will also be made to test for unusual sex ratios.
PROGRESS: Spawning of Tilapia aurea was studied in steel tanks with concrete floors, under various photoperiods. Sex ratio was 5 males to 25 females per tank, using tanks that were 198, 259, and 330 cm in diameter with 56 cm depth water. Using this set-up, mortalities by fighting were eliminated. Fourteen hours of light followed by 10 hours of dark achieved more spawn than any other light regime studied. Under 0, 6, and 24 hours of light per day the fish were found to produce diminishing amounts of eggs until nearly stopping production at 9 weeks. Ten hours light per day, 12 hours light per day, and a treatment of 10 minutes of light each hour for 12 hours per day induced fish to spawn but at lower levels than the 14-hour photoperiod. Results show that tilapia could be spawned year-round with a 14-hour photoperiod (with water temperature at 26 degrees C). Further research is being conducted to find optimum densities, water depth, sex ratio, and tank size for the hybridization of tilapia to produce all male offspring.
SUPPORTED BY Colorado State Government

3.0008,
WETLANDS DISPOSAL OF GEOTHERMAL WASTEWATER
L. Ischinger, U.S. Dept. of the Interior, Fish & Wildlife Service, *Fort Collins, Colorado* (B827B-863)
OBJECTIVE: To determine the feasibility of using spent geothermal waters for the creation or enhancement of waterfowl wetland habitats in the arid western U.S.
APPROACH: Evaluate existing chemical and physical data, waterfowl and foodstock tolerances, legal and institutional implications, and physical changes associated with the objective, and selected sites based upon developed criteria.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

3.0009,
REMOTE SENSING GEOTHERMAL
K. Watson, U.S. Dept. of the Interior, Geological Survey, Geologic Division, *Box 25046, Denver Federal Center, Denver, Colorado* 80225 (9790-00922)
To extend the use of a theoretical thermal model to more complex geological situations including topographic and surface-roughness effects, to develop computer methodology for registration of aircraft images acquired at different times in the diurnal cycle and apply these techniques to the analysis of multispectral data acquired for the island of Hawaii. Also to digitally enhance LANDSAT images of part of the Cascade Range, interpret these scenes for geologic linear features, and statistically analyze significant trend directions and spatial distribution patterns. Results of these analyses will be applied to delineating major geologic structures in the Cascade Range and evaluating their possible control on geothermal reservoirs.
SUPPORTED BY U.S. Dept. of the Interior, Geological Survey, Geologic Div.

3.0010,
PROJECT TO DEFINE A RURAL GEOTHERMAL RESOURCE DEVELOPMENT AND APPLICATIONS PROGRAM - INSTITUTIONAL ARRANGEMENTS/MECHANISMS WORK PLAN
K. Baskette, U.S. Four Corners Regional Commission, *c/o U.S. Dept. of Commerce, Room 81898-C, Washington, District of Columbia* 20230
SUPPORTED BY U.S. Dept. of Energy

3.0011,
GEOTHERMAL FORESTRY DEMONSTRATION AND RAFT RIVER INVESTIGATIONS
D.R. Ralston, University of Idaho, College of Mines & Earth Resources, Dept. of Geology, *Moscow, Idaho* 83843 (EY-76-S-07-1638)
SUPPORTED BY U.S. Dept. of Energy

3.0012,
FISH
G.W. Klontz, University of Idaho, Forest Wildlife & Range Experiment Station, *Moscow, Idaho* 83843 (IDA-CFU-0057)
OBJECTIVE: Assess the economic feasibility of raising fresh water fin fish in geothermal waters.
APPROACH: The objective will be attained by raising carp and channel catfish in natural geothermal waters and in non-geothemal waters. The growth rates, hematological parameters, bioaccumulations of heavy metals, and proximate analyses of white muscle will be measured and used as validating criteria.
SUPPORTED BY Idaho State Government

3.0013,
COMMERCIAL FEASIBILITY OF CULTURING FISH IN GEOTHERMAL WATER
M. Beleau, University of Idaho, School of Forestry Wildlife & Range Sciences, Dept. of Fisheries, *Moscow, Idaho* 83843 (EW-78-S-07-1757)
SUPPORTED BY U.S. Dept. of Energy

3.0014,
REGIONAL GEOTHERMAL HYDROLOGY OF SOUTHWESTERN MONTANA
R.B. Leonard, U.S. Dept. of the Intenor, Geological Survey, Water Resources Div., *Helena, Montana* (MT 75-052)
Thermal springs are widely distributed in southwestern Montana, and regional heat flow is higher than

normal. Thermal water is believed to underlie an extensive area, and it may be an important resource for development as geothermal-energy research and exploration expand and as thermal water not hot enough for power generation in operating plants comes into wider use. The magnitude of this resource, and its occurrence, temperature, and chemical character are poorly known, and optimum development will require rational exploration and evaluation.

The objectives of the study are to (1) describe the areal distribution, depth of occurrence, temperature, and chemical character of the thermal waters in part of southwestern Montana, (2) determine the nature of the geologic controls on occurrence of the thermal waters, and (3) develop conceptual models of the hydrothermal flow systems, to provide a rational basis for appraisal and potential development of the resource.

(1) Review literature for data on geology, hydrology, temperature, hydrochemistry, and geophysics. (2) Inventory springs and wells, both thermal and nonthermal, in thermal-spring areas; measure temperature, chemical character, head, and discharge periodically and analyze typical waters for chemical load. (3) Study geology, particularly structural features, of thermal-spring areas, to develop conceptual models of the hydrologic system. (4) Design and carry out a program of test drilling to provide critical hydraulic, geophysical, temperature, and hydrochemical information. Items 3 and 4, will be coordinated with related activities of other investigators making geologic and temperature studies.

Thermal springs exceeding 38 degrees C at 24 sites in southwestern Montana appear to be surface expressions of deep circulation of water in faults and fractures along a slightly higher than normal geothermal gradient. Evidence for recent volcanism is lacking except in the vicinity of Yellowstone Park. Propsects for shallow high temperature reservoirs suitable for power generation are poor. However, continuing detailed studies at representative sites demonstrate that many of the thermal waters from springs and shallow wells at temperatures up to 90 degrees C are suitable for space heating, bathing, aquaculture and similar uses. Concentrations of fluoride and radioactivity were measured. (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of the Interior, Geological Survey, Water Resources Div.

3.0015,

GEOTHERMAL RESOURCE FOR DIRECT APPLICATION IN TOMATO GROWING AND BUILDINGS PROJECT

Unknown, Moapa Band of Paiute Indians, *P.O. Box 56, Moapa, Nevada* 89025

SUPPORTED BY U.S. Dept. of Energy

3.0016,

PRODUCTION OF MACROBRACHIUM ROSENBERGII (GIANT MALAYSIAN PRAWN IN NEVADA)

R. Taylor, University of Nevada, Reno Campus, Max C. Fleischmann College of Agriculture, Dept. of Veterinary Medicine, *Reno, Nevada* 89507 (NEV00355)

OBJECTIVE: Determine the feasibility of raising prawns in power plant effluents and/or geothermal waters in Nevada.

APPROACH: Obtain prawns, conduct liveability tests, prepare for production. Grow larvae in brackish water, prepare ponds and study pond water parameters. Stock ponds with juveniles, feed, maintain and harvest adults. Study market.

PROGRESS: One 1/4 acre pond was stocked with 16,000 M. rosenbergii juveniles which averaged .2 to 2.0 grams. Water temperatures averaged 83 degrees F for the first 60 days but then dropped to 72 degrees F for the next 120 days. The pond was harvested at 203 days stocking when water temperatures were below 70 degrees F. Total harvest of the pond yielded 6461 prawns (40% survival) weighing 264 pounds or apprpoximately 1059 lbs/acre. Forty-four pounds of 9 count prawns were used in a marketing study and the remainder returned to the pond. During the year a raceway, 6 research ponds, a 3/4 acre pond and a 1 acre pond were constructed for use during 1979.

SUPPORTED BY Nevada State Government

3.0017,

STUDY THE PRACTICALITY OF UTILIZING GEOTHERMAL RESOURCES FOR A NEW CORN PROCESSING PLANT

S.V. Cabibbo, Burns & Roe Industrial Services Corp., Dept. of Natural & Industrial Resources, *P.O. Box 663, 283 Rte. 17, Paramus, New Jersey* 07652 (4862-01)

The project objective is to develop a base of engineering, economic, and institutional data which can be used to assess the practicality of utilizing the geothermal resources of an East Mesa, California, site for a planned new corn processing plant. The approach is to: predict expected range of relevant geothermal reservoir data; develop a design concept for the entire geothermal energy system; perform a parametric analysis of capital and operating costs; and analyze relevant institutional relations. The expected results include detailed design package including process flow sheets, instrumentation diagrams, site plans, plant arrangement drawings and functional specifications for all new equipment; an evaluation of the economics of using geothermal energy in place of all or part of conventional energy sources; and a consideration of ways to eliminate any institutional barriers against the proposed application.

SUPPORTED BY U.S. Dept. of Energy

3.0018,

GEOTHERMAL APPLICATIONS TO INTEGRATED FEEDLOT AND FARMING OPERATIONS

Unknown, J.A. Albertson Land & Cattle, *Nyssa, Oregon* 97913

SUPPORTED BY U.S. Dept. of Energy

3.0019,

ECONOMIC EFFICIENCY, EQUITY, & IMPACT ASSOCIATED WITH GEOTHERMAL RESOURCE DEVELOPMENT IN OREGON

F.W. Obermiller, Oregon State Higher Education System, Oregon State University, Agricultural Experiment Station, Dept. of Agriculture & Resource Economics, *126 Agriculture Hall, Corvallis, Oregon* 97331 (ORE00111)

OBJECTIVE: Inventory the location and extent of developable geothermal resources in Oregon for different energy prices and investment costs; evaluate private benefits and costs of geothermal development for different leasing arrangements, ownership structures, degrees of risk and uncertainty, energy prices, and BTU-equavalency values; evaluate public benefits and costs of geothermal developing including effects of different State and/or federal regulations and formulate recommended guidelines as appropriate.

APPROACH: Assemble and catalogue secondary data on Oregon geothermal resources; simulate costs and returns to private geothermal resource owners and public resource managers for alternative combinations of natural and market risk and uncertainty, energy prices, and development costs; project local economic effects for each alternative using a county-level input-out-put model; evaluate time paths of social benefits and costs using regionalized benefit-cost analysis.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Oregon

3.0020,

HEAT TRANSPORT IN GROUNDWATER SYSTEMS

D.L. Reddell, Texas A & M University, College Station Campus, Texas Water Resources Inst., Dept. of Agricultural Engineering, *College Station, Texas* 77843 (A-039-TEX)

Low grade heat from geothermal sources is presently available in many aquifers. In addition, a system has been proposed in which large quantities of groundwater are heated by solar heaters and the hot water injected into aquifers for long-term storage. The hot water would be pumped back to the surface for space heating during cold weather. Quantities of hot water in the form of waste heat is also available for storage underground in some areas.

Several hydrological and environmental problems exist for systems in which hot water is either injected or reclaimed from groundwater aquifers. This project will develop tools and procedures whereby the economic and environmental feasibility of such a hot water injection system could be evaluated at any location. Objectives of this research are: (1) Develop a computer simulation of the simultaneous movement of mass and energy (heat) in a groundwater aquifer with fluid density and viscosity variations, (2) Verify the numerical model with laboratory and field hot water injection systems, and (3) Evaluate the feasibility of storing hot water in groundwater aquifers.

SUPPORTED BY U.S. Dept. of the Interior, Office of Water Research & Technology

3.0021,

FLORAL GREENHOUSE INDUSTRY GEOTHERMAL ENERGY DEMONSTRATION PROJECT

R.M. Wright, Utah Roses Inc., *567 W. 90th S., Sandy, Utah* 84010 (AC07-79ET27056)

The objectives are to drill a geothermal well on the location of the existing greenhouse, and to heat the greenhouses with the geothermal fluids obtained from the well. This will also demonstrate the use of geothermal energy for space heating applications in a populated area, as well as the availability of geothermal energy in the Salt Lake City area and other similar locations in the western US. After the well is successfully completed, the greenhouse will be retrofitted to utilize the heat, depending on water temperature and water characteristics. If sufficient flow and temperature is developed, hot water will be offered to surrounding homes and businesses in a district heating project.

SUPPORTED BY U.S. Dept. of Energy, Idaho Operations Office

3.0022,

UTILIZATION OF GEOTHERMAL ENERGY IN AGRICULTURE

D. Pasternak, Ben Gurion University of the Negev, Research & Development Authority, *P.O. Box 1025, Beersheba, Israel*

OBJECTIVE: The water of most of the Middle East and Northern Africa brackish water aquifers is warm. The objective of this project is to design optimal integrated systems for the agricultural utilization of the geothermal energy and of the brackish water.

APPROACH: The relatively high winter solar radiation, relatively mild water temperatures and the proximity to Western Europe have turned Israel into a major supplier of out of season vegetables and flowers to Europe. The utilization of geothermal energy for soil and/or space heating in greenhouses further augment these advantages. The heat is utilized before the water is pumped to irrigate field crops.

PROGRESS: Systems for soil warming with geothermal waters have been developed and tested. Crop reactions to soil temperatures have been established. A system for space warming with low heat (25-40 degrees C) waters is being developed. It is based on a double-layer roof and a 'water curtain' as heat exchangers.

Ecological parameters for terrestrial studies: Latitude, 31 degrees, zero minutes; Altitude, 350 meters; Soil types, sand to loam; Mean annual temperature, 20 degrees C; Months of greatest moisture, January-February; Growing season, 365 days; Mean annual rainfall, 105 mm; Mean annual humidity, 50 percent; Number of wet seasons, one.

SUPPORTED BY Ministry of Energy

3.0023,

TEMPERATURE MEASUREMENT IN EARTH MASS WITH HOSE SYSTEMS FOR SOIL HEAT

R. Pusch, University of Lulea, Geotechnical, *S95187 Lulea, Sweden* (780674-3)

BFR is financing a soil heat project. This is supplemented in the above mentioned project with temperature measurements in an earth mass in Pitea where a hose system for soil heat has been installed.

The aim is to determine, during the 3-year observation period, the seasonable dependency of the temperature as a result of the heat extracted and of groundwater fluctuation. This will also constitute valuable information for the major soil heat project and will include information on the risk of the occurrence of permafrost.

SUPPORTED BY Statens Rad for Byggnadsforskning

4. ENERGY FROM AGRICULTURAL PRODUCTS AND RESIDUES

4.0001,

ENERGY IN WESTERN AGRICULTURE - REQUIREMENTS, ADJUSTMENTS, AND ALTERNATIVES

M.A. Altobella, University of Arizona, Agricultural Experiment Station, Dept. of Agricultural Economics, *Tucson, Arizona* 85721 (ARZT-171562-52-20)

OBJECTIVE: Examine and analyze adjustments which might result from changes in prices and supplies of energy resources, and consequent impacts on Pinal County agriculture. Assess contributions of, and prospects for, alternative technologies and policies for dealings with changes in energy availability.

APPROACH: Linear programming models will developed for representative-farms in Pinal County. Adjustments to changes in prices, supplies and technologies will be projected using parameteric linear programming techniques.

PROGRESS: An economic assessment of methane gas conversion from feedlot animal waste has been completed. This analysis incorporates technological learning functions into a dynamic investment analysis. The research indicates that under current economic conditions methane generation is not economical at all levels of application. For larger feedlots which incorporate economies of size, it may be adoptable in the near future. Additional progress was made in the area of economic impact of energy on irrigated agriculture in Arizona. This analysis examines the changes in cost of production and technological adjustment under conditions of varying energy prices. Research continuned on the management economics of solar powered irrigation pumping. This research incorporates a Farm Management Model to examine the efficient use of a solar power unit in Central Arizona. An additional area of research was begun on 'Baysian Analysis in Irrigation Decision Making for Groundwater Use.' This project explicitly incorporates risk into the decision analysis.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Arizona

4.0002,

METHANE GENERATION FOR WASTE WATER GROWN AQUATIC PLANTS

Unknown, Solar Aqua Systems, *Encinitas, California* 92024 (EM-78-G-0D-1949)

SUPPORTED BY U.S. Dept. of Energy

4.0003,

SYNTHESIS AND DEGRADATION OF ORGANIC COMPOUNDS BY SAPROPHYTIC BACTERIA

H.A. Barker, University of California, Berkeley Campus, Agricultural Experiment Station, Dept. of Biochemistry, *Berkeley, California* 94720 (CA-B#-BCH-1207-H)

OBJECTIVE: Role of specific nutrients; detect growth factors; biosynthesis of cellular constituents; metabolism of specific nitrogenous substrates; fatty acid synthesis and degradation with enzymatic preparations derived from C. Kluyveri; determine large scale culture requirements for C. Kluyveri; determine and study bacteria involved and mechanism of methane production from known natural substrates; study carbohydrate and other non-nitrogenous transformations, and CO(2) utilization in relation to anaerobic production of acetic acid; study decomposition of pear waste by nitrogen fixing bacteria and nitrogen fixation in cell-free extracts of C. Kluyveri.

APPROACH: Studies of the glutamate isomerase and mesaconase reactions have been continued and studies of the enzymatic biosynthesis of coenzyme B(1)(2) from vitamin B(1)(2) have been initiated.

PROGRESS: Three enzymatic activities involved in the degradation of L-Beta-lysine by Pseudomonas B4 have been extensively purified. The 3-keto-6-acetamidohexanoate cleavage enzyme has been purified 38 fold with a 10% yield; a 4-acetamidobutyryl-CoA hydrolase has been purified 51 fold in a 13% yield; and a 4-acetamidobutyryl-CoA deacetylase was purified 11 fold in a 5% yield. The latter two activities appear to be associated with the same protein. In a study of the chemistry of 4-acetamidobutyryl-CoA conversion to acetate, 4-aminobutyrate and coenzyme A, we have shown that several postulated intermediates, namely, 4-acetamidobutyrate, 4-aminobutyryl-CoA, the lactam of 4-aminobutyrate, and the N-acetyl derivative of the lactam of 4-aminobutyrate are not converted to acetate or 4-aminobutyrate. The 3-keto-6-acetamido cleavage enzyme hhas been shown to catalyze a reversible reaction, and the substrate specificity of the enzyme has been shown to differ from that of the 3-keto-5-aminohexanoate cleavage enzyme of clostridia.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

4.0004,

BIOCONVERSION OF CELLULOSE

C.R. Wilke, University of California, Berkeley Campus, Lawrence Berkeley Lab., *Berkeley, California* 94720

Investigation of sugar and ethanol production based on the carbohydrate content of cellulosic materials; hydrolysis of cellulose to sugars and subsequent fermentation to ethyl alcohol; chemical and enzymatic pretreatment of cellulosic materials to remove lignin and hemi-cellulose; enzymatic hydrolysis of alpha-cellulose to glucose; fermentation of pentoses and hexoses to ethanol; kinetics of enzymatic hydrolysis; continuous process for cellulose enzyme production; adsorption for enzyme recovery; new ethanol fermentation method using vacuum and dense yeast cultures; form of stored solar energy. (DOE/ER-0002)

SUPPORTED BY U.S. Dept. of Energy, Office of Energy Research

4.0005,

SPECIES CONTROL IN LARGE SCALE ALGAE BIOMASS PRODUCTION

W.J. Oswald, University of California, Berkeley Campus, School of Engineering, Dept. of Civil Engineering, *Berkeley, California* 94720 (EY-76-S-03-0034-251)

SUPPORTED BY U.S. Dept. of Energy

4.0006,

UTILIZATION OF ANIMAL, CROP AND PROCESSING RESIDUES

J.B. Dobie, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Davis, California* 95616 (CA-D#-AER-2971-H)

OBJECTIVE: Investigate means and processes for obtaining greater utilization of animal, crop and food processing plant wastes by recycling, conversion and energy recovery techniques. Control and reduction of air, water and soil pollution would be a basic consideration.

APPROACH: Laboratory and field studies would be conducted on open field burning of crop residues and pyrolysis and incineration for any recovery; animal and food processing wastes would be examined for recycling to animal feeds; all types of wastes would be studied in soil plots for recovery of nutrients and encouragement of soil bacteria conversion to useable plant nutrients.

PROGRESS: A rotary screen was used to separate soil and some leaf fines from plant material at a commercial gin during the 1977 ginning season. Gasification tests with the cubed plant materials showed that ash slagging is as serious problem with a down-draft gasifier. Trials have been run on composting screened cotton gin trash. The optimum composting moisture content is 35% with a mixing frequency of 4-7 days. Weed seeds and verticillium wilt organisms appear to be destroyed in the composting process and the reduction of several pesticides is presently being assayed. Several studies have been made on producing methane gas from dairy manure, tomato cannery waste and barley straw. When combining several wastes for methane digester feed the optimum combinationappears to be for a 'non-lignin carbon to nitrogen' ratio of 25 for the mixture. Studies with operating digesters with a relatively high solids content (20% TS) have been successful. A project was completed on characterizing the wastewater from egg grading plants. Samples from several plants over a 10 week penod indicated the organic content of the effluent to be about ten times as strong as domestic sewage. The wastewater was found to be amenable to both aerobic and anaerobic biological stabilization. The 3m 3 chicken manure digester studies continued with a range of volatile solid loading rates at 25-day and 15-day hydraulic detention times.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

4.0007,

BIOCONVERSION OF DISTILLERY AND WINERY WASTE

L.A. Williams, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Viticulture & Enology, *Davis, California* 95616 (CA-D#-VIT-3841-H)

OBJECTIVE: Develop bioconversion processes based on winery and distillery wastes which allow economic recovery of by-products or energy while reducing pollution problems.

APPROACH: Survey and chemically characterize winery and distillery waste streams. Survey and screen for organisms which perform interesting bioconversions of waste or its major components. Determine important bioconverison process parameters such as kinetic constants, yield factors, temperature limits, etc. in labortory scale equipment. Perform economic analysis to determine desirability of pilot scale experiments.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

4.0008,

POULTRY PRODUCTION AND ENVIRONMENTAL QUALITY

W.O. Wilson, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Avian Science, *Davis, California* 95616 (CA-D#-AVS-3372-RR)

OBJECTIVE: Determine characteristics of poultry house pollutants and factors influencing their relationship to environmental quality. Determine the effects of poultry house environment and management practices on production efficiency and product quality.

APPROACH: Data from laboratory studies on methods of stabilizing poultry manure to make it less attractive to flies will be collected. Field studies will be made to compare different housing types, e.g., deep pit, flush-out, and open houses, as sources of ammonia, odor and dust. An experimental model of an anaerobic digestor of poultry manure will be operated at different loading levels to determine the amount of methane generated. The residue will be studied as a fertilizer and possibly as an animal feedstuff. Noise inside several houses filled with chickens will be characterized with regard to its frequency range and decibel level.

PROGRESS: A number of open and environmentally controlled poultry houses were studied for light intensity, relative humidity, noise level, dust level, ammonia concentration and air movement. The data will appear in the final report of the regional project W-136. The work on various loading rates of volatile solids as influencing gas production from chicken manure was continued and the final report is under compilation. If the regional project is extended further, characterization of poultry house dust will be started.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

4.0009,

ON-SITE STABILIZATION OF DAIRY AND BEEF CATTLE WASTES

A.C. Chang, University of California, Riverside Campus, Agricultural Experiment Station, Dept. of Soil & Environmental Sciences, *Riverside, California* 92502 (CA-R#-SES-2774-H)

OBJECTIVE: Investigate the feasibility of on-site decomposition of animal wastes, determine the movement of pollutants and simulate the management system mathematically.

APPROACH: Survey the present waste management practices; laboratory and field studies to determine the environmental effects on the rate and degree of waste stabilization; determination of nutrients movement and transport of heavy metal ions during the process; construction and verification of the mathematical model; and estimation of management alternative.

PROGRESS: In recent years, there is a renewed interest in producing methane gas by anaerobic fermentation of organic wastes. The gas producing potential of each waste, however, can only be estimated by using the cumbersome bench scale bio-assay procedure. A study was initiated to develop a quick method to assess the anaerobic digestibility of organic wastes. The development of this procedure is based on correlating biodegradability with the thermal destruction of the waste. Preliminary investigations using municipal sewage sludge digesters demonstrated good relationships of anaerobic solid destruction and thermal destruction. Plans were made to set up bench scale anaerobic digesters character-

izing anaerobic degradability of various animal wastes and testing the aplicability of the proposed quick method in determining digestibility.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

4.0010,
CONVERSION OF FEEDLOT WASTE INTO SINGLE CELL PROTEIN ANIMAL FEED
J.M. Harper, Colorado State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fort Collins, Colorado* 80523 (COLV02879)
OBJECTIVE: Agricultural waste can be a resource for feed and fuel production instead of a pollution burden. Animal manure represents the most concentrated and must abundant form of this resource.
APPROACH: The main ingredients in feedlot waste are undigested cellulose and nitrogenous compounds. These ingredients may be converted to a valuable feed called single cell protein, or to fuel by microbial fermentation.
SUPPORTED BY U.S. Dept. of Agriculture

4.0011,
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
S.M. Morrison, Colorado State University, College of Veterinary Medicine & Biomedical Sciences, Dept. of Microbiology, *Fort Collins, Colorado* 80523 (COL00222)
OBJECTIVE: Develop optimal animal manure management systems to meet revolving environmental and economic requirements and be compatible with the increasing needs for animal protein; investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses with consideration of the human, animal and plant health factors.
APPROACH: Examine the role of feedlot waste (FLW) particle size on chemically modifying manure for fermentations and explore dual culture (mold and yeast) fermentations process as a means of converting cellulosics to carbohydrates for yeast protein growth. Study harvesting practices to provide greatest retention of valuable manure constituents while minimizing detrimental envoronmental impacts. Modified manures are to be examined as substrate for optimizing bacterial methane production. Further evaluation of the sodium content in feeds to be made to reduce runoff salt pollution by better management of feeds. Use of solar radiation transparent coverings over feedlot area to eliminate precipitation, evaporate feedlot moisture and reduce volume of manure to manage as well as odors is to be examined.
PROGRESS: Enzymatic hydrolysis of whole feedlot waste (FLW) has shown the cellulosic portion is directly converted, without prior modification, to glucose and other reducing sugars by cellulase complex from Trichoderma viride. Supplementation of T. viride cellulase with Aspergillus niger B-glucosidase (cellobiase) enhances cellulose conversion. Hydrolysis is done in presence of toluene to inhibit microbial utilization of sugars. Filtrates contain reducing sugars representing 50% conversion of FLW cellulose. This efficiency compares with 60-70% yields from extensively treated cellulose. Direct enzymatic hydrolysis of FLW cellulose provides substantial economic improvement for FLW utilization. Potential of beef FLW as substrate for microbial methane production has been studied in batch and two-stage systems. In batch tests, time to methane production is dependent upon initial loading up to 8%; 6% was most efficient for total CH(4) and CH(4)/gram manure. In first week a 4-log decline in methanogens occurred. Carbon compounds are not limiting for CH(4) production. Redox potentials were steady after day 3. (Text Truncated - Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Colorado

4.0012,
OPTIMIZATION OF ENERGY USE FOR LIVESTOCK PRODUCTION
G. Ward, Colorado State University, School of Agricultural Sciences, Dept. of Animal Sciences, *Fort Collins, Colorado* 80523 (INT79-18660)
The objective of this collaborative research with Professor N. Todorov of the Agricultural University in Stara Zagora, Bulgaria, is to modify and use mathematical models to integrate the results of a variety of research programs at the Colorado State University and in Bulgaria into a system for analysis of alternative uses for crop residues and agricultural wastes. A number of mechanical, chemical and enzymatic methods to improve nutritive value of biomass will be evaluated and the cost effectiveness and net energy efficiency for field use will be determined. The analysis of research data from Colorado State University and Bulgaria will determine the most advantageous alternative uses of wastes for feed, fertilizer and fuel. This cooperative research is being performed under the NSF-Bulgarian program.
SUPPORTED BY U.S. National Science Foundation, Directorate for Scientific Technological & Internat. Affairs, Div. of International Programs

4.0013,
COMPETITION FOR RURAL RESOURCES
M. Skold, Colorado State University, U.S. Dept. of Agriculture Natural Resource Economics Div., *Fort Collins, Colorado* 80523 (NRE-43-322-08-01)
OBJECTIVE: Develop functional relationships for the supply of land to agriculture and among competing uses, relating land availability to commodity prices, commodity policies, resource policies, non-agricultural competing uses and other significant variables. Relate agricultural land availability to agricultural capacity and develop linkages between policy variables and the amount of land used and agricultural capacity.
APPROACH: Develop a system to account for land use changes over time as between agricultural uses, abandonment, reclamation, by irrigation or drainage, recreation, forestry, urbanization and surface mining. Use economic theory, models and statistical techniques to estimate functions relating land use for various purposes to explanatory variables. Using a regional definition system consistent with other projects and progress areas of the Division and of the Commodity Economic Division, integrate land supply among competing uses by region. In cooperation with other Divisions, integrate land supply estimates with estimates of input supplies, yield projections and other measures of productivity to capacity of agriculture.
PROGRESS: The year provided evaluations of the nature and extent of competition for rural resources from several sources. The actual withdrawal of land and water from agricultural production for surface mining will have rather minor consequences to agricultural output potentials. Preliminary analyses reveal the biomass energy could be competitive with returns from non-irrigated agricultural production at cost of about $3 per 10 BTU's. Without significantly increased costs of alternative energy sources, land and water use for biomass production are not economic at the present. Should biomass production become feasible, sizable amounts of land would be required. Research on the effects of urbanization and population growth on agriculture across the U.S. has revealed that each one percent increase in population density in urban areas is associated with a 1.05% increase in farmland values. Examination of the factors associated with groundwater irrigation development in the Central and Southern Plains have not reached any conclusions. The effects of energy prices and availabilities on these agricultural production systems are significant, however.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Natural Resource Economics Div.

4.0014,
MARKET POTENTIALS FOR U.S. FARM PRODUCTS IN DOMESTIC AND FOREIGN MARKETS
P.B. Dwoskin, U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div., *14th & Independence Ave. S.W., Washington, District of Columbia* 20250 (NEA-12-108-11-00)
OBJECTIVE: Determine foreign market needs and requirements for food and fiber products to identify U.S. market expansion opportunities. Evaluate market penetration of new or modified highly processed foods and their impacts on marketing and food cost, along with the factors associated with product successes or failures. Assess the size and characteristics of industrial markets and the techno-economic requirements of industrial and uses for agricultural products and byproducts.
APPROACH: A general analytical approach will be imployed, utilizing data generated by audit and survey techniques to examine foreign market requirements and impacts of new food forms on food cost. On-site surveys, economic-engineering techniques including cost-benefit analyses will be used in analyzing the feasibility of converting agricultural raw materials into fuel, fertilizer, etc.
PROGRESS: An investigation of the impact of highly processed food products (convenience foods) on food costs. Convenience foods comprise more than a third of total food expenditures. Only 36% of the 162 processed foods studied had a comparative cost advantage over their non-processed counterpart. However, this does not take into account possible savings in preparation time, etc. Most (80%) of the 'new generation' convenience foods were more expensive than their fresh or home-prepared counterpart. Research also has been completed on the U.S. and Japanese fast food industry, foreign market activities of U.S. food manufacturers, and a study of a new hide-to-leather processing method. Major findings were: (1) fast food industry represents a $6.4 billion market for food in the U.S. and a $655 million foreign market potential by 1980; (2) based on 1974-1975 growth rates, Japan's fast food industry will offer an export market potential of almost $.5 billion for food and equipment by 1979; (3) most food processors (8 in 10) are in or plan to get into foreign marketing; and (4) a new hide-to-leather processing method did reduce water pollution, lowered processing costs and provided higher valued leather hides for export markets.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div.

4.0015,
UTILIZATION ECONOMICS AT THE REGIONAL RESEARCH LABORATORIES
M.E. Miller, U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div., *14th & Independence Ave. S.W., Washington, District of Columbia* 20250 (NEA-12-107-11-00)
OBJECTIVE: Provide economic advisory services to the Regional Research Laboratories to assist them in the formulation and conduct of the utilization research program of the Department. Determine utilization patterns for proudcts of the different regions and their comparative economics as a basis for providing guides on product and process improvements and enhancing their utilization through new intra and inter-regional uses. Evaluate user reaction and conduct market tests on selected products to improve properties and assist in commercialization of laboratory developed products.
APPROACH: A wide spectrum of economic analytical techniques will be employed, using primary and secondary data sources. Economic advisory services are provided based on secondary data supplemented if appropriate by case studies, particularly in evaluating the performance of new technological development.
PROGRESS: Assessments are made on the feasibility and impacts of new and emerging technology. Use of solar energy is not economically feasible for most applications in agricultural production and processing, but technical progress and changing price relations could significantly improve prospects for feasibility within a decade. Conversion of crop residues to energy products through incinerations, pyrolyses, hydrogassification or fermentation may be feasible in a limited number of specific situation, but widespread adoption by farmers is not now feasible. It is economically feasible to include crop residues in beef cattle growing and maintenance rations, especially if the rations are balanced with grain and supplements. However, the potential for increasing amounts of crop residues fed cattle is limited by the value of leaving the residues on the land for fertility and conservation purposes, costs of collecting, differing geographical concentrations of beef cattle and residues, and other factors. Potential savings of computer-assisted checkout systems in food retail stores are an estimated 1% of gross sales; costs of the systems can be recovered within 3-5 years. A Delphi type of study done cooperatively with the Office of Technology Assessment identifies the emerging technologies in food marketing warranting priority in use of resources for technology assessment. A draft plan for assessing the impacts of agriculturl sciences and technologies was completed.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, National Economic Analysis Div.

4.0016,
WATER HYACINTH WASTEWATER TREATMENT SYSTEM
R.J. Fox, Reedy Creek Improvement Dist., *P.O. Box 40, Lake Buena Vista, Florida* 32830 (L822C-049)
The purpose of this project is to demonstrate an innovative and environmentally sound water hyacinth wastewater treatment system designed to recycle water and nutrients. Specific goals: meet tertiary effluent standards of 5 mg/l biochemical oxygen

demand (BOD) and suspended solids (SS), 3 mg/l nitrogen (N), 1 mg/l phosphorus (P); secondary system removal capability of 85% BOD and 75% SS from primary sewage. The approach is to operate a 50,000 GPD wastewater treatment system, monitor the system and all related activities and determine the capability of the system to meet the above objectives. Phase I of the plan will design, construct, and operate the system for 18 months; monitor system, analyze effectiveness and publish periodic reports and final Phase I report. As a separate activity, conduct studies to determine (1) biomass characterization/growth optimization of the water hyacinth and (2) the energy conversion potential of the hyacinth through anaerobic digestion.

Preliminary design criteria should be developed for water hyacinth treatment systems receiving municipal wastewater. Data from this project are to be utilized for design of a 1.0 MGD treatment facility.

PROGRESS: The experimental facility has been constructed, and changes in water quality are being monitored. The experimental facility has been constructed and tests initiated to determine the treatment effectiveness of the system for inputs of primary sewage effluent.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Robert S. Kerr Environmental Research Lab.

4.0017,

ANIMAL HEALTH AND FOOD SAFETY ASPECTS OF FEEDING ANIMAL WASTE

R.L. Shirley, State University System of Florida, University of Florida, Agricultural Experiment Station, Dept. of Animal Science, *Gainesville, Florida* 32601 (FLA-AL-01931)

OBJECTIVE: Develop methods of processing animal waste feeds that eleminate hazards from pathogenic microorganisms, microbial toxins and internal parasites. Establish the concentration of mineral elements in processed animal wastes and determine the accumulation and depletion of these elements in the tissues or products of the receipient animal.

APPROACH: Mix sodium choloride to whole cattle blood at various levels (0,6,9,12, 15 and 18%) to prevent coagulation and mix treated blood in diets fed steers in a 5x5 Latin square metabolism trial. TDN, ME, and N retention will be determined in the diets. Anaplasmosis and leptospirosis tests on the blood of the steers fed the blood diets will be made. Bacterial counts will be made on the diets. Add chlorine compounds to blood treated with NaCl, mix indiets and feed steers as above. Feed steers diets that contain varying levels of the microbial residue after methane generation from cattle manure. The diets will be evaluated for TDN, ME, NE(m) and NE(g) by the California net energy system. The diets and tissues of the steers will be evaluated for potentially toxic minerals as HG, Pb, Cd, Ni, Cu, and Zn. Steaks will be evaluated for overall acceptability.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Florida

4.0018,

METHODS AND EQUIPMENT TO IMPROVE DRYING AND CLEANING OF PEANUTS

P.D. Blankenship, U.S. Dept. of Agriculture, Agricultural Research, National Peanut Research Lab., *P.O. Box 110, Dawson, Georgia* 31742 (7704-20592-007)

OBJECTIVE: Develop improved methods, techniques and equipment for drying and cleaning of peanuts to maintain quality, reduce energy consumption, improve efficiency, reduce unit cost; and enhance domestic and foreign consumption.

APPROACH: Explore the feasibility of cycling peanut drying to reduce the electrical power requirement during peak-use periods. Evaluate off-cycle periods of 1, 2, 4 and 6 hours for preventing peanut quality deterioration and providing optimum use of energy. Explore the use of timers, limit switches, and shut-off valves for controlling or cycling the drying equipment. Explore the feasibility of using the heat from burning waste (foreign material, peanut hulls, etc.) to supplement the energy requirement for drying peanuts. Develop improved equipment for cleaning peanuts both at the warehouse and the shelling plants.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Georgia - South Carolina Area

4.0019,

STRUCTURE AND BIOGENESIS OF MEMBRANES OF METHANOGENIC BACTERIA

R.A. Makula, University of Georgia, Franklin College of Arts & Sciences, Dept. of Biochemistry, *Athens, Georgia* 30601 (PCM78-22911)

In recent years, interest in microorganisms capable of producing methane from carbon dioxide and hydrogen has greatly increased due to their economic potential for production of methane. The discovery that these microorganisms may constitute a distinct phylogenetic group of ancient origin has served to enhance this interest. Studies are outlined for the investigation of ether containing lipids in these microorganisms; isolation of intracytoplasmic membranes; ultrastructural studies of intracytoplasmic membrane; and the biogenesis of intracyto-plasmic membranes correlated with the production of methane.

SUPPORTED BY U.S. National Science Foundation, Directorate for Biological Behavioral & Social Sciences, Div. of Physiology Cellular & Molecular Biology

4.0020,

RESOURCE RECOVERY FROM LIVESTOCK WASTES

G.L. Newton, University of Georgia, Georgia Coastal Plain Experiment Station, Dept. of Animal Science, *Tifton, Georgia* 31794 (GEO00271)

OBJECTIVE: Determine if deep-pit stored manure can be used for methane production and the feeding value of digester sludge. Develop means of reducing the nitrogen loss from oxidation ditches. Develop ways of utilizing fibrous materials removed from the stream of a flush waste removal system. Determine if certain algae can be used effectively to produce a usable product from waste waters. Incorporate procedures for resource recovery into systems and evaluate the practicality.

APPROACH: Waste from beef, dairy and swine research units will be available for research on recovery of livestock waste material. Both laboratory and larger scale research studies will be initiated to evaluate the component parts of the waste material for feed, fertilizer and gas production. At the same time, environmental pollution will be monitored.

PROGRESS: Nitrogen, at rates of 224, 448 and 672 kg/ha, from either ammonium nitrate or liquid beef cattle wastes was applied to Coastal bermudagrass and Pensacola bahiagrass sod plots for a second year. At the highest rate, greater accumulations of soil nitrate were found in the manured plots, with essentially the same accumulations at the lower rates. Greater accumulations of nitrate were also found beneath bahiagrass than beneath bermudagrass. Soil pH continued to be greater on manured plots. Soil potash levels were similar for manured and chemically fertilized plots but chemically fertilized plots tend to have greater concentrations of soil phosphate. Forage dry matter yield for manured plots averaged only 61% of that for chemically fertilized plots. A higher percentage of applied ammonia nitrate N was recovered in bermudagrass forage but a higher percentage of manure N was recovered in forage on bahiagrass plots. Fertilization of bahiagrass at the two highest rates damaged the bahiagrass sod such that other plants were dominant on some of these plots. It was found that solids separated from the waste stream of a recycle-flush swine unit could be preserved with organic acids or formalin. In a cafeteria trial, sows preferred propionic acid treated material. Treated material was fed (70% of DM) to two gestating sows during the latter 2/3 of gestation. Sows gave birth to and weaned as many pigs as sows fed a conventional diet, although the pigs were slightly lighter at birth.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Georgia

4.0021,

LOW COST POND DIGESTERS FOR HAWAII PIG FARM ENERGY NEEDS

M.H. Weitzenhoff, (No Performing Organization Reported), *Hawaii* (EM-78-G-03-1912)

SUPPORTED BY U.S. Dept. of Energy

4.0022,

BIOGAS ENERGY FOR HAWAII SMALL FARMS AND HOMESTEADS

M.H. Weitzenhoff, (No Performing Organization Reported), *Hawaii* (EM-78-G-03-1985)

SUPPORTED BY U.S. Dept. of Energy

4.0023,

PAPAYA DRYING AND WASTE CONVERSION SYSTEM

Unknown, La Maloo, *Pahoa, Hawaii* 96778

SUPPORTED BY U.S. Dept. of Energy

4.0024,

ENERGY IN WESTERN AGRICULTURE - REQUIREMENTS, ADJUSTMENTS AND ALTERNATIVES

C. Gopalakrishnan, University of Hawaii System, Manoa Campus, Agricultural Experiment Station, Dept. of Agricultural Economics, *Gilmore Hall, Room 102, Honolulu, Hawaii* 96822 (HAW00455-F)

OBJECTIVE: Estimate current patterns and amounts of energy inputs currently utilized in Western agriculture. Examine and analyze adjustments which might result from changes in prices and supplies of energy resources, and consequent impacts on Western agriculture. Assess contributions of, and prospects for, alternative technologies and policies for dealing with changes in energy availability.

APPROACH: Will gather data and develop coefficients of energy use for major agricultural commodities. Per unit energy requirements for specific commodities and total energy requirements for Hawaii's agriculture will be developed. Impact of changes in energy prices and supplies on the cost structure of enterprise activities will be studied. Potential for alternative energy-saving technologies and policies will be explored.

PROGRESS: Completed a major part of a comprehensive survey of energy requirements for Hawaii's pineapple industry. Specific accomplishments: (1) Collected information hitherto unavailable on the direct and embodied energy needs of Hawaii's pineapple industry. Specific information on amount of electricity, gasoline, diesel fuel, fuel oil and propane used for on-farm production, transportation, and processing was compiled. (2) The economic feasibility of using pineapple biomass (green chop and bran) as a source of energy is being explored. (3) A paper on some methodological aspects of energy requirements estimation has been accepted for presentation at the annual meeting of the Western Regional Science Association to be held in San Diego in February 1979. The project has also moved into other innovative areas: (1) preliminary work has started on the estimation of energy requirements for aquaculture, identified as one of the State's potential growth-industries; (2) initial discussions with the State's Department of Planning and Economic Development (DPED) concerning possible collaboration in estimating the State's energy requirements in the agricultural sector.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Hawaii

4.0025,

DESIGN PARAMETERS AND EQUATIONS FOR ANAEROBIC BIOCONVERSION OF ORGANIC WASTES

P. Yang, University of Hawaii System, Manoa Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gilmore Hall, Room 102, Honolulu, Hawaii* 96822 (HAW00528-S)

OBJECTIVE: Evaluate the rate constants (based on biological concepts) and equations for the design and prediction of production of methane and degree of stabilization of organic waste in the batch, semi-continuous flow with constant solid recycle systems. Investigate the operational stability of constant sludge recycle system at normal and shock loading conditions.

APPROACH: Laboratory and pilot scale operations will be used for the evaluation of design parameters for batch operations. These parameters will be applied as the design criteria for the development and operation of semi-continuous flow and constant sludge concentration recycled continuous flow systems. Animal wastes, crop residues, and sewage treatment sludge will be used for demonstrating the application of design parameters evaluated from laboratory and pilot scale studies.

PROGRESS: Three types of organic wastes, including pig manure, spent fruit fly medium and seaweed, were studied. For pig manure, semi-continuous flow operation of a baffled 208-liter of metal drum was operated. It was found that the bio-gas production ranges from 0.66 to 9 liter per gram of TVS removed within hydraulic detention time of 30 and 16 days, respectively. Research is still in progress to determine the role of a baffled digester for improvement of gas production. One type of flexible plastic bag digester (20 m 3) has been installed on one com-

mercial pig farm. Studies of this unit include reaction kinetic characteristics and enhanced energy (methane) production from digestion of mixed culture of algae grown from digested pig wastes. Use of an anaerobic fermentation process to treat spent fruit fly media wastes is not practical and feasible. Difficulty in controlling pH is the main reason for failure of such an operation. Seaweed, such as Eucheuma sp and Ulva sp, were used for anaerobic digestion. It was found that: (1) Bio-gas yield value of Ulva sp (0.8 ml/mg) is four times higher than the Eucheuma sp (0.2 ml/mg); (2) relationship between specific gas production rate and initial biodegradable substrate concentration can be expressed as hyperbolic pattern; (3) percent of methane in the total gas production is 64 to 72% by using semi-continuous flow system with sludge retention time of 20 days.

SUPPORTED BY Hawaii State Government

4.0026,

MANAGEMENT AND UTILIZATION OF REARING WASTE FROM MASS REARING OF FRUIT FLIES

P.Y. Yang, University of Hawaii System, Manoa Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Gilmore Hall, Room 102, Honolulu, Hawaii* 96822 (5090-20225-005-A(1))

OBJECTIVE: Develop improved methods for managing waste resulting from mass rearing of fruit flies to reduce total cost of operating rearing facilities.

APPROACH: Evaluate methods for accumulation and handling of fruit fly waste and investigate methods for waste disposal and utilization, including the production of methane gas and devising ways to use such gas to help meet heat energy needs of an insect-rearing facility.

PROGRESS: A partial aerobic treatment process with incorporation of protein recovery has been determined to be the most suitable biological treatment for spent fruit fly larval diets. Through a 6-month period operation of semi-continuous flow with 5-day detention time, it was found that up to 85% of the soluble chemical oxygen demand material could be removed. The solid part recovered from the process was further dewatered and fed to prawns. It was found that, when a mixture of half regular feed and half processed material was fed to prawns, the best results were achieved in regard to increase of body weight, mortality and homogenous growth rate.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, California - Hawaii - Nevada Area

4.0027,

HAWAII ETHANOL FROM MOLASSES PROJECT (PHASE I)

C.S. Chen, University of Hawaii System, Manoa Campus, Research Corp., *Bachman Hall, Honolulu, Hawaii* 96822

SUPPORTED BY U.S. Dept. of Energy

4.0028,

CONFERENCE - ALTERNATIVES IN ANIMAL WASTE UTILIZATION

J.P. Fontenot, American Society of Animal Science, *113 N. Neil St., Champaign, Illinois* 61820 (L617D-022)

The main objective of the conference is to examine in depth the feasibility of the various alternatives in utilization of animal wastes. Previous symposia and conferences have covered only one of the potential uses of the waste. The different alternatives will be critically evaluated by top specialists in the various disciplines. Publication of the documented papers will provide reference material which is not presently available.

A 1-day conference will be held at the annual meeting of the American Society of Animal Science, Madison, Wisconsin, July 27, 1977. The conference will consist of formal presentations by speakers with time for discussion after each major section. Each speaker will submit a manuscript in proper form for publication in the Journal of Animal Science. The papers will be reviewed by the Editorial Board of the Journal of Animal Science. Following appropriate revisions, they will be published as a group in one issue of the Journal. Reprints will be available and several will be supplied to EPA.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Robert S. Kerr Environmental Research Lab.

4.0029,

SYMPOSIUM - MANAGEMENT AND UTILIZATION OF ANIMAL WASTES

A.L. Sutton, American Society of Animal Science, *113 N. Neil St., Champaign, Illinois* 61820 (L770D-063)

The objective of this symposium is to discuss advancements in the state-of-the-art in certain areas of the management and utilization of animal wastes with pollution abatement. Scientists attending this symposium will be exposed to research information, critical evaluations and practical experiences related to waste processing and refeeding, regulatory concerns, methane digesters and other nutrient recovery systems, new waste handling techniques and economic comparisons of waste management systems. This symposium is designed to critically evaluate and share experiences on these topics by researchers, businessmen and regulatory officials involved in these areas.

The ultimate benefit of this symposium is that from the information presented, scientists, environmentalists, regulatory agencies, livestock producers, and the general public will know (1) what management systems appear useful in efficiently utilizing nutrients in waste while controlling pollution and (2) what problems exist with current management systems and future research information needs.

A one-half day symposium will be held during a joint annual meeting of the American Society of Animal Science and American Dairy Science Association, East Lansing, Michigan, July 9-13, 1978. Manuscripts of the symposium will be published in the Journal of Animal Science.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Robert S. Kerr Environmental Research Lab.

4.0030,

INNOVATIVE FERMENTATION TECHNOLOGY FOR ALCOHOL PRODUCTION

R.J. Bothast, U.S. Dept. of Agriculture, Agricultural Research, Northern Regional Research Center, Engineering Development Lab., *Peoria, Illinois* 61604 (3102-20540-028)

OBJECTIVE: Increase the efficiency of alcohol fermentation through development of new fermentation processes, by selection of microbial strains with greater fermentative ability, and by application of secondary fermentations to better utilize process by-products.

APPROACH: Develop and evaluate novel fermentation processes for converting glucose to alcohol. Evluate selected microorganisms for their ability to produce increased levels of fermentative enzymes that can more effectively convert substrates to alcohol. Assess selected microbial strains and new isolates for their ability to produce alcohol under a variety of fermentation parameters, i.e., batch, continuous, cell recycle, and immobilized cells-enzymes. Explore efficient production of alcohol through fermentations of distressed or modified grains. Evaluate methods for further fermentation of process byproducts after recovery of protein.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Northern Regional Research Center

4.0031,

INCREASED ENERGY EFFICIENCY OF SUBSTRATE PREPARATION FOR ALCOHOL FERMENTATIONS

R.W. Detroy, U.S. Dept. of Agriculture, Agricultural Research, Northern Regional Research Center, Fermentation Lab., *1815 N. University St., Peoria, Illinois* 61604 (3102-20540-027)

OBJECTIVE: Develop new chemical and biochemical systems to more efficiently convert plant polysaccharides to fermentable sugars and recover nutrients from fermentation byproducts in order to decrease the energy required for alcohol production.

APPROACH: Investigate new biological, chemical, physical or integrated processes for saccharification of grain starch in contrast to the traditional energy-intensive process. Apply biological and/or chemical procedures to grain and crop residues to render starch and lignocellulosics more amenable to subsequent enzymatic hydrolysis to fermentable sugars. Evaluate biochemical and chemical delignification of lignocellulosic agri-resdues. Select microorganisms capable of preferential biodelignification of residues. Explore a cellulase-catlyzed hydrolysis of lignocellulosics to glucose coupled with direct yeast fermentations. Develop methods for the useful recovery of protein from distiller's grains.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Northern Regional Research Center

4.0032,

MICROBIOLOGY OF THE THERMOPHILIC METHANOGENESIS IN CATTLE WASTE

M.P. Bryant, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Dairy Science, *Urbana, Illinois* 61801 (ILLU-35-0331)

OBJECTIVE: Obtain fundamental information on the microbial and biochemical ecology of the bacterial system involved in production of methane from cattle waste under thermophilic conditions (60 C) so that detailed information will be available concerning the pathways of metabolism, major kinds of bacteria responsible for specific metabolic reactions and metabolic and nutritional interactions involved in efficient methanogenesis.

APPROACH: Isolate and characterize the major groups of bacteria involved in rapid and efficient degradation of organic matter of cattle waste to methane and CO(2) under anaerobic conditions at 60 C. Major emphasis will be placed on bacteria responsible for fiber, protein and lipid degradation, those involved in degrading intermediates such as fatty acids to acetate, and species directly producing methane from acetate and hydrogen and determination of features of importance to establishment of their specific functions in the ecosystem.

PROGRESS: Further studies on the importance of the methyl group of acetate in methanogenesis from dairy cattle waste in reactors fed 6% organic matter at 10-day retention time and 60 degrees C were conducted using continuous infusions of 2- 1 4C-acetate. Results indicated that 90% of the methane was produced via acetate. Further studies documented that a thermophilic species of the genus Methanosarcina is active in acetate degradation under these conditions. This genus was not previously known to contain thermophilic species and the thermophilic species responsible for acetate degradation was not previously known. Studies on efficiency of methane production from whole dairy wastes as compared to fluid from the same dairy waste after large-particle solids removal with a Surge solids-liquid separator, showed that about 84% or more of the organic matter (OM) from which methane is produced was associated with the liquid. Methane from whole waste average 156 ml/day/g OM fed and from the liquid, 173 ml. It is evident that the large-particle solids can be removed and utilized for other purposes with little effect on methane production or fertilizer value of the waste. Methane production from waste (4.1% OM in the feed) fermented at 60 degrees C (162 ml/day/g) was as efficient as that at 40 degrees C (166 ml/g) even though retention times were shorter for the 60 degrees reactors (3 and 6 days).

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Illinois

4.0033,

ELECTROCHEMICAL CONVERSION OF BIOMASS INTO PROTEIN AND HYDROGEN

D.L. Day, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Urbana, Illinois* 61801 (ILLU-10-0376)

OBJECTIVE: Investigate technical and economic feasibilities of electrochemical oxidation of biomass to produce feed protein and by-product hydrogen, safe handling and storage of hydrogen, and hydrogen-oxygen fuel cell production of d.c. electricity.

APPROACH: Liquid swine manure will initally be the biomass to be converted in bench scale electrochemical cells. Aerobic bacteria will utilize oxygen as it is produced at the anodes and hydrogen, and energy source, will be produced and collected at the cathodes. The hydrogen will be utilized in a fuel cell to produce d.c. electricity to supplement operation of the electrochemical cell. Technicl operational parameters will be studied to achieve optimum growth of single cell protein and production of hydrogen. Conditions promoting additional production of hydrogen from biomass by anaerobic bacteria will also be studied.

PROGRESS: The prospect of using electrolytic oxygen to replace mechanical aeration, where the electrochemical process converts organic wastes into high quality protein and produces hydrogen as a by-product, is being studied. After testing several cell designs, we constructed an electrolytic cell using Dimensionally Stable Anode (DSA) as the anode, steel as the cathode, and a cloth diaphragm sandwiched between the electrodes. Two electrode pairs are joined into an electrode assembly with the cathodes on the inside so hydrogen is collected between them. The fermenting waste, electrolyte, is kept in a plexiglass box with two electrode assemblies suspended in it. The cell is designed for continuous

operation with drip feed of diluted waste and constant overflow of effluent. A DC power supply is set at 2.8 volts and the current maintained at 250 milliamps. An anerobic tank and a tank aerated by bubbling air through it are simultaneously operated as controls. Effluents from the 3 tanks were tested for protein concentration, chemical oxygen demand, ammonia, total nitrogen and odor. The tests results for the electrolytic cell were not significantly different from the aerobic tank and both assimilated organic matter faster and had significantly less odor than the anerobic tank. While these results are encouraging, calculations indicated that the electrochemical cell is more expensive than mechanical aeration.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Illinois

4.0034,
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S-NUTRITIVE VALUE OF OXIDATION DITCH RESIDUES
A.H. Jensen, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Animal Science, *Urbana, Illinois* 61801 (ILLU-20-0395)
OBJECTIVE: Investigate use of by-products of annual manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses with consideration of the human, animal and plant health factors.
APPROACH: Procedures-Aerobically-processed wastes will be fed to supplement the regular diet of swine.
PROGRESS: Oxidation ditch mixed liquor (ODML) was further evaluated for nutritive contribution to finishing pig diets. Two hundred and eighty-eight finishing pigs were used (6 groups of 6 pigs each per dietary treatment). Treatments were either tap water or ODML as source of drinking water with experimental diets of (1) fortified corn: soybean meal 14% crude protein mixture, (2) diet 1 minus riboflavin, niacin, pantothenic acid and B(12) supplementation, (3) diet 1 minus calcium and phosphorus supplementation, and (4) diet 1 minus both the vitamins and calcium and phosphorus. Pigs receiving tap water had higher (P less than .05) gain, feed intake and gain/feed than those receiving ODML. Vitamin supplementation had no apparent effect. There was an interaction (P less than .05) for water source and calcium and phosphorus supplementation. Average assay values of weekly ODML samples for a 6-week period were 502 ppm nitrates, 42922 C.O.D., 4.8% solids, 24 degrees C and 7.7 ph. A second experiment was conducted to evaluate the effects of different dietary levels of dried swine feces on acceptability of the diets by young pigs. Feces were collected in a metal tray under a slotted-floor pen housing ten finishing pigs. They were fed a 14% fortified corn: soybean meal diet. The feces were dried in a drying oven (135 degrees F), then ground and mixed with the diets. Levels of 2.5 or 5.0% of dried material replaced an equal amount of weight of yellow corn. Diets were fed either in meal or pellet form.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Illinois

4.0035,
SOLIDS-LIQUID SEPARATION OF ANIMAL WASTE
S.L. Spahr, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Dairy Science, *Urbana, Illinois* 61801 (ILLU-35-0353)
OBJECTIVE: Evaluate the liquid and the solid components resulting from mechanical separation of dairy manure for their on-farm use via refeeding, use bedding, generation of methane, and use as fertilizer.
APPROACH: The washed, fibrous portion will be evaluated via feeding trials as a feed for replacement heifers. Effects of ensiling and the addition of supplements at various levels will be determined. The fiber will be evaluated for bedding in free stalls with investigations designed to determine the microbiological safety of this practice relative to mastitis. The liquid portion will be recovered and evaluated for recycling as a pre-separation diluent in place of fresh water, as a source for on-farm generation of methane, and as a crop fertilizer.
PROGRESS: Installation of a perforated roller design solids-liquid separator unit for animal waste was completed at the University dairy farm. Tests were conducted with waste from dairy cows to determine the operational characteristics of the system under on-farm conditions with low (4-5%), medium (6-7%) and high (9-10%) solids content in the influent. Dry matters of the separated fiber without second stage washing were: low-25.8%, medium-27.0%, high-32.0%; values with washing were: low-26.2%, medium-27.1%, high 28.3%. Solids contents of the first stage effluent with and without second stage washing were: low-4.2 and 4.4%, medium-5.6 and 5.7%, high-7.9 and 7.8%; values for second stage effluent were: low-4.3 and 3.3%, medium-4.7 and 4.3%, high-6.9 and 6.2%. A greater percentage of the solids in the influent was recovered in the fiber fraction with high solids than with low solids in the influent. Increased influent flow rate with medium solids content had no effect on fiber moisture content, percent of influent solids separated as fiber, or percent solids of first and second stage effluent. The fiber produced by this separator had very little odor, did not stain, and had excellent handling characteristics. Approximately three times as much electrical energy was used per unit of fiber separated from low solids influent as was used from high solids influent.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Illinois

4.0036,
BIOLOGICAL CONVERSION OF BIOMASS TO METHANE
J.T. Pfeffer, University of Illinois, Urbana Champaign Campus, School of Engineering, Dept. of Civil Engineering, *106 Engineering Hall, Urbana, Illinois* 61801 (EY-76-S-02-2917)
The object of this study is to evaluate the potential for recovery of methane, a fuel gas, from various sources of organic residue and crops. A semipilot-scale conversion system was used to obtain data in the effect of process variables on the product (methane) yield. Variables investigated include retention time, fermentation temperature and pretreatment techniques. Data concerning the materials handling properties of the process slurries are being collected. Characteristics of the residue as related to the processing for reclamation or ultimate disposal are being investigated, and the dewatering properties of the fermented slurry are being determined. Organic residues investigated included beef feedlot manure, corn stover and wheat straw. Data collected in these studies will be used to evaluate the economic feasibility of converting the various feed stocks into a fuel gas.
SUPPORTED BY U.S. Dept. of Energy

4.0037,
ANIMAL WASTE MANAGEMENT AND TREATMENT FOR MAXIMUM ENERGY RECOVERY
A.C. Dale, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND046015)
OBJECTIVE: Review results of research on the utilization of animal wastes by both crops and animals to determine the relative values of each method of use for conserving nutrients and organic matter; review information on the conservation of nutrients and energy (organic matter) by various waste management systems; determine the apparent nutrient value of animal wastes using present systems versus newly developed systems or systems made biochemically inactive; apply wastes stored by the above methods to crops to determine differences in value.
APPROACH: The method approach in objectives one and two is mainly a review of present research results to determine value of waste as a feed and as a plant food. Samples will be taken from present system with nutrient and energy losses evaluated as compared to a 'no-loss' and biochemically inactivated system. Finally, applications of the wastes to crops will be made to determine effectiveness of each system selected for conserving nutrients and energy and releasing them for plant use.
PROGRESS: Digestion of cattle waste in a fiber wall reactor (FWR) was compared to digestion in a conventional high rate digester (HRD). porous membrane was employed in the fiber wall reactor to act as a site for the growth of bacteria. A series of four 3.8 liter digesters were maintained at 35 C and continuously mixed for each digester type. Both series of digesters were under steady state conditions at detention times of 60, 40, 20 and 15 days. The waste feed was passed through a solids-liquid separator with 0.3 mm openings prior to collection in order to remove the larger manure solids. Dependent parameters measured were electrode potential, pH, total and suspended solids, alkalinity COD, gas production and composition, total Kjeldahl and ammonia nitrogen, and volatile acids. The best performance, for both digesters, occurred at detention times of 30 and 20 days. At 15 days detention time, the HRD units did not perform as well as at 20 days, while the FWR units performed nearly as well at 15 days as at 30 and 20 days. Gas composition averaged 62% methane for both types of digesters. Gas production from the FWR units averaged 0.42 mm per kg VSS added while the HRD units averaged 0.34 m per kg VSS added. Volatile suspended solids reductions averaged 83.5% in the FWR units and 50.6% reduction in the HRD units. (Text Truncated - Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Indiana

4.0038,
FUELS FROM BIOMASS:
M.R. Ladisch, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND46064)
OBJECTIVE: A new approach is under study whereby the energy needed to produce anhydrous from dilute alcohol is 1/10 of the energy contained in the final product. This is possible by combining partial distillation with chemical drying agents. Drying agents including metal oxides and hydroxides, sulfate salts and acids, cellulose, starch, and cellulosic residues will be studied with respect to equilibria, capacities, optimum conditions for use and regeneration, durability, and cost. The most suitable will be integrated into a bench-scale process. Successful development will help to give a positive energy balance for production of alcohol from plant matter.
APPROACH: Dehydrating agent effectiveness will be studied with respect to temperature, vapor rate and starling alcohol concentration. Mass and energy balences will be calculated for the dehydration step alone and for dehydration combined with partial distillation. Chemical analysis will be based on gas and liquid chromatography and Karl-fischer water analysis. Runs will be made with both reagent-grade ethanol as well as fermentation broths.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Indiana

4.0039,
ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S
J.C. Nye, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (IND46033R)
OBJECTIVE: Develop optimum animal manure management systems to meet the evolving environmental and economic requirements. Characterize atmospheric contaminants and develop abatement methods. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients and other potential uses. Characterize the non-point pollution water runoff sources from livestock and poultry enterprises.
APPROACH: Livestock production system will be modeled and the waste management components will be designed in a computer program. The concentration of volatile fatty acids in livestock waste will be measured as chemical and enzyme odor control products are added to the waste. The symbiotic growth of algae and bacteria will be studied as means to conserve nitrogen and produce a high quality protein supplement. Infiltration areas will be monitored as a means to control runoff.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Indiana

4.0040,
DRYING GRAIN WITH HEAT FROM CROP RESIDUES AND SOLAR ENERGY
G.H. Foster, Purdue University, School of Agriculture, Dept. of Agricultural Engineering, *Life Sciences Bldg., West Lafayette, Indiana* 47907 (3090-20593-032-A)
OBJECTIVE: Develop, evaluate & demonstrate a farm grain drying system using heat from renewable resources by testing a combination high-temperature/low-temperature drying system using crop residues as fuel for the high-temperature phase & solar energy for the low-temperature phase.
APPROACH: Develop a non-fossil fuel drying system that will handle approximately 500 bushels of 25% moisture corn daily, regardless of weather. Determine airflow and solar heat requirements and demonstrate the use of solar energy for drying corn in storage bins filled by layers with either freshly harvested corn or partially dried corn from a high temperature batch dryer. Evaluate quality characteristics of corn dried. Develop combustion methods for extracting stored solar heat from corn cobs and related

crop residues, including: Equipment and methods for mechanically introducing cobs into the combustion device. Controls necessary to assure adequate and safe operation of the dryer using crop residues as a fuel. A combustion gas-drying air heat exchanger.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Illinois - Indiana - Ohio Area

4.0041,

A JOINT U.S. TAIWAN EXCHANGE PROJECT ON UTILIZATION OF CELLULOSTIC MATERIALS

G.T. Tsao, Purdue University, School of Chemical Engineering, *Executive Bldg., West Lafayette, Indiana* 47907 (INT7824292)

This award provides travel support in two consecutive years for Professor George T. Tsao and Dr. L.F. Chen, both of Purdue University Laboratory of Renewable Resources Engineering to cooperate with investigators in Taiwan on the general research subject of cellulosic conversion. Dr. Tsao will cooperate with Prof. W.M. Lu, National Taiwan University, on the study of solvent disruption of the crystalline structure of cellulosic wastes. Dr. Chen will cooperate with Dr. Paul Ma, Food Industry Research Institute, and with Dr. Ming Yu, Industrial Technology Research Institute, on the production of fermentable sugars and starch-like materials from cellulosic wastes. Each investigator has different but complementary objectives in pursuing his particular subproject, while all share the common interest of exploring potentially useful processes of cellolosic conversion, particularly of cellulosic wastes such as rice hulls. The cooperation will facilitate the exchange of differing expertise, experimental procedures, experimental data, economic analyses, cellulosic materials, enzymes microbial cells, etc., contributing to progress of the research of each investigator and to the overall subject area.
SUPPORTED BY U.S. National Science Foundation, Directorate for Scientific Technological & Internat. Affairs, Div. of International Programs

4.0042,

AN INTEGRATED FARM ENERGY SUPPLY SYSTEM FOR THE IOWA FARM

W.F. Buchele, Iowa State University of Science & Technology, Iowa Agricultural & Home Economics Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (IOW02312)

OBJECTIVE: Develop and promote the use of farm size distilleries in an integrated energy system for the Iowa farm. Develop and promote the use of corn-cob gasifiers on tractors in an integrated energy system for the Iowa farm.

APPROACH: Chemical and engineering analysis will be used to disign, construct and develop a corn-fed farm size distillery and a corncob producer gas generator.

PROGRESS: Information has been gathered relating to corn milling, cooking and fermenting to beer, and on requirements for a successful on-farm distillation process. Lab scale tests relating alcohol yield to fineness of corn grind and type and quantity of enzymes and yeasts have been conducted. Major portions of the distillery (cooking and fermentation tanks, heat exchangers, distillation column) are designed and constructed and the still is being assembled. Pumps are being selected and ordered. While this project envisions using agricultural bio-mass as the energy source for cooking and distillation, the still will initially be operated on steam from the ISU power plant.
SUPPORTED BY Iowa State Government

4.0043,

DEVELOPMENT OF BIO-MASS SYSTEMS FOR DRYING CORN

W.F. Buchele, Iowa State University of Science & Technology, Iowa Agricultural & Home Economics Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (IOW02325)

OBJECTIVE: Design, construct, develop, test and promote the use of a cornstalk fueled furnace for grain drying bins. Both direct and heat exchanger furnaces will be developed.

APPROACH: Conbustion engineering and grain drying principles will be combined to produce an economical design of a cornstalk fueled furnace. Controls will be developed to operate the furace and control the hot air supply to the grain bin.

PROGRESS: Performance tests of an existing direct-fired cornstalk burning furnace have been conducted to determine airflow rates, exhaust gas temperatures, and furnace efficiencies. Equipment to measure exhaust gas composition was not available. Cornstalks from the current season (1978) and year old stalks stored as unsheltered stacks were burned. No difficulty was encountered in burning stalks of 30% moisture content (wet basis). Investigation of available domestic and foreign bio-mass fired furnaces is presently underway to identify the design features that should be incorporated into our next furnace to automatically regulate rate of burning (heat output) and to improve efficiency.
SUPPORTED BY Iowa State Government

4.0044,

ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S

R.J. Smith, Iowa State University of Science & Technology, Iowa Agricultural & Home Economics Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (IOW02126)

OBJECTIVE: Conceptualize, develop, analyze and optimize animal manure management systems with least cost and energy requirements for pollution control compatible with changing socio-politico-economic patterns. Specific objectives are: Develop optimal animal manure management systems to meet the evolving environmental and economic requirements and be compatible with the increasing needs of our nation and the world for animal protein. Characterize atmospheric contaminants and develop abatement methods to eliminate the contaminants potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses with consideration of the human, animal and plant health factors.

APPROACH: Pilot scale work on surface aeration of lagoons will be scaled up for a full size lagoon. Results obtained from a 100 gallon existing anaerobic digester will be extended to a pilot scale unit for several beef animals. Cooperative work with animal scientists will determine the feasibility of using digester effluent to produce stover silage. Observer panels will correlate odors from various livestock production systems with chemical odor standards.

PROGRESS: The treatment of manure from a swine growing-finishing unit (Unit K), using artificial marshes, concluded after a second summer of operation. Sparganium eurycarpum survived the winter poorly. Typha glauca performed best, showing no signs of stress at any loading rate. Liquid loading rates on two experiments were increased for 1978, and recirculation from the overflow pond was reduced. Water treatment by the system was very good; the overflow pond showed little turbidity (COD about 60 mg/L). Aesthetically and functionally, the marsh system surpassed an anaerobic lagoon. Analysis of the dust-borne odorous compounds in Unit K entered a quantitative phase. Obtaining contaminant-free reagents has been difficult. Starch was classified into various particle-size ranges by sedimentation in ethanol so that an artificial dust could be used for odor bearing; particle size ranges obtained were unsuitable. An odor splitter (75 mm x 75 mm duct with splitter and charcoal filter) was constructed and installed in one wall of Unit K. Preliminary results with an odor panel are encouraging. (Text Truncated - Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Iowa

4.0045,

BEEF PRODUCTION USING MANURE AND CROP RESIDUES FOR MAJOR FEED SOURCES AND METHANE PRODUCTION

R.L. Vetter, Iowa State University of Science & Technology, Iowa Agricultural & Home Economics Experiment Station, Dept. of Dairy & Animal Science, *Beardshear Hall, Ames, Iowa* 50010 (IOW02179)

OBJECTIVE: Evaluate a beef cow-calf nutrition and management program over a 3-year period which utilizes crop residues and excreta from confined feedlot cattle as the major feed sources. Evaluate the use of crop residues and animal wastes in growing rations for calves and yearlings compared with conventional feedstuffs, primarily corn silage. Compare the composition, ensiling characteristics and nutritional value of animal wastes collected and processed by the methods: direct scrapings from feedlot floor; solids from a flush system; slurry from an anaerobic digester. Evaluate on a year-round basis, the effects of extreme environmental changes experienced in the upper Midwest on the composition and ensiling characteristics of feedlot cattle wastes. Develop complete engineering plans and specifications for a heated (95 F), mixed digester that will process the manure from 30 beef animals. Monitor digester operations. Examine certain physical and chemical properties of the digested effluent. Develop a scraped surface heat changer for recovering heat from the digester effluent and transferring this heat to the influent manure slurry.

APPROACH: Use 120-head cow herd and calves for 3-year study of beef production with the developed feed resources. Supporting laboratory research. Phase development of waste handling systems and characterization of wastes. Seale up of anaerobic digester develop concepts.

PROGRESS: Excreta silage was made from cattle manure scraped from a solid floor and mixed with ground corn, dried molasses and chopped corn stover or ground cobs in proportions of 35:20:5:40 on a DM basis and stored in an oxygen-limiting structure. Excreta silage was fed ad libitum over 112 days to cattle (300 kg starting weight) supplemented with ground corn at the rate of 0, 0.33, 0.67, and 1.0% of body weight. Respective daily grains were 0.64, 0.93, 1.07, and 1.16 kg for heifers and 0.82, 1.08, 1.07 and 1.19 kg for steers. Net energy values for the excreta silage calculated from these data using NRC values for corn as reference were 1.30 Mcal/kg for maintenance and 0.80 Mcal/kg for gain. Metabolic profiles (38 blood parameters) from cows fed excreta silage were normal suggesting no metabolic disturbances in cattle fed excreta. Work has continued on heat transfer and mixing requirements in a 400-1 pilot digester. (Text Truncated - Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Iowa

4.0046,

STUDY AND LABORATORY EXPERIMENTS ON A FAST ANAEROBIC METHANE FUEL SYSTEM

C.D. Finney, Natural Dynamics, *Des Moines, Iowa* 50311 (EY-76-C-02-2900)
SUPPORTED BY U.S. Dept. of Energy

4.0047,

EQUIPMENT FOR RESEARCH ON BIOCONVERSION OF CELLULOSE INTO GLUCOSE AND ALCOHOL

S.D. Bassi, Benedictine College, Undergraduate School, Dept. of Biology, *Atchison, Kansas* 66002 (CDP80-17526)

This award makes it possible to acquire a spectrophotometer, glucose analyzer, and incubator/shaker. In recent years there has been a marked renewal of interest in enzymatic saccharification of cellulose. After evaluating the process, it appears that there are severe technical and economic constraints, including limited availability of suitable substrates; necessity of costly pretreatments of substrates such as corncobs, cornstalks, sawdust, etc; and the high cost of the enzyme obtained from the mold Trichoderma reesei. Yet cellulose is the only renewable resource available in billions of tons annually. The investigator proposes to continue research seeking ways to 'coax' Trichoderma into producing a surplus of the enzymes which will produce glucose from cellulose. Much of the research effort will be devoted to optimizing fermentation conditions (pH, temperature, dissolved oxygen, media, combinations of more than one mold) and to inducing mutations by using UV-radiation and selecting for the hypercellulolytic mutants. This research will be significant because the procedures developed will convert cellulose-rich materials to glucose, which will in turn be converted into alcohol and used as automotive fuel.
SUPPORTED BY U.S. National Science Foundation, Office of Planning & Resources Management, Div. of Budget & Program Analysis

4.0048,

ANAEROBIC DEGRADATION (METHANE FERMENTATION) OF BENZENE RINGS IN PLANT MATERIAL (BENZOIC ACID)

L.R. Fina, Kansas State University, Agricultural Experiment Station, Dept. of Biology, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00641)

OBJECTIVE: Gain possible insight as to how plant material containing aromatic rings (such as lignin) is degraded anaerobically. Determine the pathway of anaerobic rupture of benzoic acid during methane fermentation.

APPROACH: Use highly enriched mixed cultures and pure cultures of methane producing organisms isolated from the mixed cultures. Sources of cultures are sewage disposal plants (anaerobic digestor), rumen of cattle, or bottom muds of ponds or swamps. Cultures from each source are enriched in all glass

fermentors. Study the mixed culture phenomenon intact and the contributions of pure isolated cultures. Isolate pure and axenic bacteria to be used for enzyme preparation. Cell free enzyme preparations to be used to study one step reactions.

PROGRESS: It was reported last year that cell-free and bacterial cell-bound lipopolysaccharide (LPS) endotoxin was found in large amounts in cattle fed grain rations. The amounts in hay fed cattle was at least one-half to one-third as great. Work to be reported at this time verifies this (see publication). There is a definite toxic effect on cattle of endotoxin or LPS. Milligram quantities injected into the jugular vein of cattle causes a severe reaction and death. It is postulated that the endotoxin is absorbed into the thoracic duct through breaks in the ruminal epithelium. All lymphatics find their way to the thoracic duct which empties into the anterior venacave. Work is in progress using chromium 51 labeled endotoxin to trace the path of the LPS. Work is continued on the anaerobic rupture of benzoic acid during methand fermentation. Two papers have been prepared and submitted for publication in Archives for Microbiology. No new results to be reported at this time.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Kansas

4.0049,

MARKETING SYSTEMS ANALYSIS OF THE GRAINS INDUSTRY

L.W. Schruben, Kansas State University, Agricultural Experiment Station, Dept. of Agricultural Economics, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00791)

OBJECTIVE: This research is to develop a computerized mathematical model of the market grains supply-marketing-demand complex to indicate the nature and extent of major economic activities and interrelationships among the grains and their substitutes and to measure the influence of changes in various sectors of the industry on the total system.

APPROACH: Build econometric and statistical models of the food and feed grain industry in order to derive normative solutions with which to compare existing practices.

PROGRESS: Major modules of the Integrated Transportation Management System (ITMS), developed as a part of this project, were transferred to and made independently operational for the first time by a commercial enterprise. The commercial enterprise, Land-O-Lakes, placed ITMS into on-line service and estimates an annual payback of 10 times cost of installation. ITMS is expected to become as important in its area of application as linear programming has become in its area. The ITMS system permits application of science to transportation management. Transportation is a major cost center in many agribusinesses. Currently it is a bottleneck in the marketing of grain. ITMS was developed specifically to solve grain transportation problems, and has been so used. However, it also has general application to help solve a wide variety of problems outside of transportation. Evidence was provided the Kansas Legislature and the U.S. Secretary of Agriculture that little or no merit exists in a major subsidy program, with present technology, for using grain as a base for making an alcohol motor fuel. Bills in the Legislature were tabled largely as a result of this research.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Kansas

4.0050,

ENERGY RELATED TECHNOLOGICAL DEVELOPMENT

W.P. Walawender, Kansas State University, Agricultural Experiment Station, Dept. of Chemical Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00946)

OBJECTIVE: This project is directed at development of a continuous pryolysis pilot plant facility for the recovery of useful products from animal wastes. Produce a synthesis gas (composed primarily of CO, H(2), CO(2) and CH(4)) from feedlot manure.

APPROACH: The development involves low pressure flash pyrolysis in a fluidized bed designed to maximize both gas yield and quality.

PROGRESS: The pilot plant for the fluid-bed gasification of agricultural wastes was made operational this year. The bulk of the gasification work has concentrated on dried feedlot manure with throughputs up to 40 lb/hr. With this feedstock we have produced a gas mixture (CO, CO(2), H(2), CH(4), C(2)H(6), and C(3)H(6)) which has a heating value of about 390 Btu/SCF (about 40% of the heating value of natural gas). When cleaned of carbon dioxide, the heating value of the gas can be increased to 530 Btu/SCF. The yield of gas is 8.3 SCF per pound of dry ash-free feed. These conditions represent a recovery of 41% of the energy content of the feed material. Overall material balances were also conducted about the pilot plant and were found to close within 95%. (This means that the material flows into the process agree with the material flows out of the process within 95%). This information is a vital input for the design of a commercial gas producer. We have also successfully operated the pilot plant with corn stover, milo stover and wood chips. Preliminary data with crop residues compares well with the data for manure. Gas produced from crop residue was found to have a heating value of 340 Btu/SCF and can be increased to 500 Btu/SCF by removal of carbon dioxide. Present plans are to work towards increasing gas yield and consequently energy recovery. We believe that energy recoveries in the range of 50-55% can be achieved with the present system.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Kansas

4.0051,

ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S

R.I. Lipper, Kansas State University, School of Engineering, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00778)

OBJECTIVE: Develop optimal manure management systems for animals in confinement housing. Investigate systems of manure management for production of methane and conservation of plant nutrients.

APPROACH: Develop design criteria, make field trials and evaluate performance of flushing gutter manure transport systems and components for livestock confinement facilities with emphasis on swine. Continue investigation of methane production from anaerobic digestion of swine manure with special reference to the role played by ammonia in the bacterial decomposition of undiluted wastes to methods of scrubbing ammonia and CO(2) from digester gases and capturing ammonia for later use as fertilizer. Measure pollution potential of stormwater and irrigation runoff from corn fields where feedlot manure has been incorporated into the soil at rates ranging from 0 to 300 dry tons per acre per year and develop a suitable field sampler for stormwater runoff.

PROGRESS: Feasibility of developing an electric motor operated slurry spinner to spread thick liquid swine manure was explored as an alternative to 'big-gun' sprinklers that have a higher energy requirement and inherently larger capacity than often is required for use by all but the largest producers. Extensive field tests were made using both water and thick swine manure slurry on spinners three different disk angles and numerous vane configurations. Data were taken on fluid flow rate, power consumption, uniformity of distribution, and diameter of coverage. Power consumption was higher and diameter of coverage was lower than was predicted from theoretical analysis. Severe break up of water droplets resulting in mist clouds limited performance very severely with water, less severely with thick slurry. Maximum diameter of coverage was approximately 54 feet. Except for wind effects, uniformity of coverage appeared to be acceptable. Designs which would minimize the fanning of air would reduce the misting effect and power requirement. None of the designs tested were deemed suitable for commercialization but numerous other designs seem possible.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Kansas

4.0052,

ENGINEERING SYSTEMS FOR MANAGEMENT AND USE OF ENERGY FROM BIOMASS

B.J. Cochran, Louisiana State University, Agricultural & Mechanical College, Agricultural Experiment Station, Dept. of Agricultural Engineering, *University Station, Baton Rouge, Louisiana* 70803 (LAB01952)

OBJECTIVE: Determine the feasibility of designing and constructing an on-farm fuel generator using biomass material as an energy source. Determine alternate means of utilizing agricultural products as sources of energy. Characterize and improve energy management strategies for environmentally and economically acceptable crop production systems.

APPROACH: Investigate the various processes known for producing fuels from biomass materials. The processes determined most feasible for farm size generators will be thoroughly evaluated using biomass materials to produce fuels. The types of materials such as crops, weeds, grasses and animal waste, capable of being converted into fuels will be determined. Fuels produced from biomass will be tested for use in internal combustion engines heating buildings and crop drying. Methods of storing fuels on the farm will be considered. Evaluate methods through systems analysis for reducing energy input to crop production. Each cropping operation will be evaluated with respect to all operations to determine the total energy effect of the operation. Techniques of utilizing some agricultural residues as energy for processing with respect to quality, management and cost will be studied. The feasibility of transporting some residue from the production area will be determined.

PROGRESS: Information was compiled from various sources and calculations were made to document the energy content of plant material. The sulphur and ash contents of plant materials was found to be reasonably low and dry plant material from all sources contains approximately the same amount of energy. Ash, extractives and water in plants are the major factors affecting their energy values. The energy value of plant material decreases with an increase in ash content and increases with an increase in extractives content. Moisture lowers the energy value because heat energy is required to vaporize the water. Seeds have relatively high energy values. Four treatments of Rio and Wray varieties of sweet sorghum were planted to determine biomass yields. The treatments included 1, 2, 3, and 4 drills planted on rows 180 cm apart. The spacing between the drills of the 2 and 3 drill treatments was 45 cm whereas the spacing for the 4-drill treatment was 28 cm.

(Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Louisiana

4.0053,

PROPOSAL TO CONDUCT A FEASIBILITY STUDY OF THE CONVERSION OF ANIMAL FEEDLOT WASTES TO USEFUL ENERGY

D.D. Culley, Louisiana State University, Agricultural & Mechanical College, School of Forestry & Wildlife Management, *University Station, Baton Rouge, Louisiana* 70803 (LA.B02022)

OBJECTIVE: To determine if a dairy farm operation can design its waste management to include a fermentation system for energy production and lagoon system for the production of edible, high protein aquatic plants and be economically feasible or competitive with current dairy farm waste management practices.

APPROACH: Dairy manure will be fermented to generate methane for use as supplemental energy. Various sludge from the fermenter will be used as a nutrient source for aquatic plants. The plants will be cycled back into the animals feed as a protein supplement and the effluent from the lagoon will be used as washwater for the feedlot. Techniques of plant harvest, transportation, and processing will be developed. An economic analysis of the total system will be undertaken to determine capital requirements, return on investment analysis, and cost and energy comparison between current dairy farm practices and a system in which wastes are managed for energy and aquatic plant production.

SUPPORTED BY Louisiana State Government

4.0054,

TIME-TEMPERATURE RELATIONS OF ENZYMATIC CONVERSION OF POLYSACCHARIDES TO SUGARS IN SWEET POTATO ROOT

J.C. Bouwkamp, University of Maryland, College Park Campus, Agricultural Experiment Station, Dept. of Horticulture, *College Park, Maryland* 20740 (MD-L-80-A)

OBJECTIVE: Determine the feasibility and yield of ethanol from sweet potatoes. Verify the dry matter yield potential of sweet potatoes grown for the full season. Determine optimum pre-fermentation conditions utilizing native and added enzymes resulting in a maximum production of ethanol.

APPROACH: Replicated yield trials will be conducted for 2 years and dry matter yield caculated. Time-temperature studies on the activity of native beta-amylase will be conducted. At the conclusion of the time-temperature study, samples will be fermented with and without added cellulase and pectinase and ethanol recovery will be determined.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Maryland

4.0055,

ANIMAL WASTE MANAGEMENT SYSTEMS FOR THE 1980'S

J.B. Gerrish, Michigan State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL01066)

OBJECTIVE: Develop optimal animal manure management systems. Characterize atmospheric contaminants and develop abatement methods to eliminate the contaminants' potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant-nutrients and other potential uses. Characterize the non-point pollution water runoff sources from livestock and poultry enterprises on pasture production systems and land areas with manure application and to further develop guidelines for abatement of non-point pollution sources from animal manures.

APPROACH: Study hydraulic transport of manure as practiced in flushing systems. This will lead to design recommendations and workable plans. Modelling studies are already well underway. In odor control, we are studying the effects of ozone on swine waste. Also studying the culture of purple sulfur bacteria as an odor modifier in anaerobic lagoons. Hope to develop procedures to foster such a culture under Michigan climatic conditions. Studying liquid-solid separation for its potential as a step in a fermentation process leading to a re-fed product. Have two year's data from some spring-thaw runoff events at system of 12 plots where manure was applied on the frozen ground. This study will continue in an attempt to develop control strategies which would minimize non-point source pollution. (20% basic research; 60% applied research; 20% development effort).

PROGRESS: Work with the anaerobic swine waste lagoons at MSU has led to new insights in design and management of such lagoons. A system involving two lagoons has been shown effective in reducing the time during which odors can be produced; the basic features of the system include a strategy to preserve a population of purple sulfur bacteria during the cold Michigan winter by maintaining one of the two lagoons in a lightly loaded state throughout the winter. In the spring it has little scum, good light penetration, and warms up quickly so bacteria become active early. A mathematical model has been developed to provide a quantitative analysis of the purple sulfur bacterial processes in a lagoon. The model predicts hydrogen sulfide production. Purple sulfur bacteria show promise of being a useful odor control mechanism for lagoons even in our cold Michigan climate. (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Michigan

4.0056,

ANIMAL WASTE MANAGEMENT SYSTEM FOR THE 1980'S

J.W. Thomas, Michigan State University, Agricultural Experiment Station, Dept. of Dairy Science, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL01078)

OBJECTIVE: Conceptualize, develop, analyze and optimize animal manure management systems with least cost and energy requirements for pollution control compatible with changing sociopolitico-economic patterns. Develop optimal animal manure management systems to meet the evolving environmental and economic requirements and be compatible with the increasing needs of our nation and the world for animal protein. Characterize atmospheric contaminants and to develop abatement methods to eliminate the contaminants potentially harmful effects on human and animal health. Investigate use of by-products of animal manure management systems for energy sources, feed ingredients, plant nutrients for crop production and other potential uses with consideration of the human, animal and plant health factors.

APPROACH: Manure simulating that in liquid manure pits but held in laboratory jars will be treated with chemicals and odor evaluated by several persons. Nitrogen loss will be measured. Excreta of different types (varying animal source and fresh or dried,etc.) and dry matter contents will be added to corn forage and the mixture ensiled. Silage characteristics and animal acceptability and performance will be measured.

PROGRESS: Lack of availability of caged layer waste has temporarily curtailed efforts to use this product in ensiled forages for dairy animals. When available the waste will be ensiled with corn forage or corn silage and tested as a supplemental protein source for growing heifers and milking cows.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Michigan

4.0057,

CONDUCT EXPERIMENTAL STUDY TO ESTABLISH TECHNICAL FEASIBILITY OF PEAT BIOGASIFICATION

A.M. Rader, Minnesota Gas Co., *Minneapolis, Minnesota* 55402

SUPPORTED BY U.S. Dept. of Energy

4.0058,

FARM ANIMAL WASTE MANAGEMENT

P.R. Goodrich, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *St. Paul, Minnesota* 55101 (MIN-12-060)

OBJECTIVE: Evaluate gases from manure for chemical components and effects on man and animals; methods of reclaiming, storing, processing and refeeding animal wastes back to animals for effect on animal health, production. Develop components for collection, storing, treating of animal manure and evaluate their economy, effect on production and their effect on environment. Evaluate effect of rates, frequency of applying animal manure to soils.

APPROACH: Manure gases have been analyzed by gas chromotograph and evaluated using human odor panels. Limited results are available relating gas composition, production to various waste management systems; effects on animal, human health and production. Reclaiming, recycling the usable constituents has been studied to determine palatability and feed conversion on a limited number of animals. Detailed investigations of toxicity, microbiological effects and residual storage of pharmaceuticals in the animal are lacking. Evaluations of separating, storing and handling systems are extremely limited and not for waste management in cold climate.

PROGRESS: The continued successful operation of a full scale anaerobic digester on a farm has shown remarkable stability and gas production. The high ph of 8 has not caused instability and gas production has reached 1.2 volumes of bio-gas per volume of digester volume. The gas quality averages 60% methane. A submerged chopper pump driven by a 10 HP motor has worked well to agitate feed material from the swine barn and feed the digester. A lower cost injector fed directly from a pump via hose injected 760 liter/min soil covered the manure well and the tractor consumed only 5.7 liters Diesel per hour. Nitrogen was conserved by not exposing the slurry to the atmosphere. Laboratory studies of an anaerobic filter for treating liquid swine wastes found that the microorganism floc did not attach to the plastic media. The floc accumulated on horizontal surfaces and in crevasses. COD removal by the filters is approximately 15-30%. Eighty percent of the gas produced is methane. Methane accounted for essentially all of the COD removal.

SUPPORTED BY Minnesota State Government

4.0059,

AN ECONOMIC ANALYSIS OF MINNESOTA FARM ADJUSTMENTS TO INCREASING ENERGY PRICES

H.R. Jensen, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural & Applied Economics, *St. Paul, Minnesota* 55101 (MIN-14-094)

OBJECTIVE: Estimate the energy embodied in capital inputs. Estimate optimum adjustments in resource use, production methods and output on representative Minnesota farms as energy prices increase. Estimate aggregate shifts in energy use and production by Minnesota's commercial agriculture as energy prices increase.

APPROACH: Firms producing livestock equipment, farm buildings and irrigation equipment will be asked to monitor all energy inputs and the amount of output produced. Mathematical programming and simulation models will be used to determine the optimum adjustment as energy prices increase. Estimates of aggregate adjustments will be prepared by solving the representative firm models and a price adjustment model in an iterative manner.

PROGRESS: The study of on-farm grain drying and storing assessed the real average cost of 8 alternative drying and storing techniques over 20 years for case farms with varying volumes of grain to dry and store. As energy prices were increased substantial savings in fuel costs were realized by systems that rely, at least in part, on grain aeration for moisture removal during drying operations. The Low Temperature and the Dryeration systems were the lowest cost systems in all situations except one, regardless of the increases in energy prices. The findings are helpful to farmers and equipments suppliers in decision making on drying and storage facilities. A systems model was developed to provide basic information on how crop and livestock production systems vary in total, direct plus indirect, energy use. The model focuses primarily on the expenditure of energy at various stages in the production and use of durable inputs, using farm machinery and livestock equipment as examples. Such energy accounting provides information on how crop and livestock production systems vary in total energy use, which is basic to establishing national energy conservation policy incentives. The study on gasohol showed that more BTU's are required to produce alcohol from corn or wheat than the alcohol contains. Moreover, with wholesale prices of gasoline between $.11 and $.23 a liter production of gasohol is uneconomic unless the grain is costless and distillers dried grain and solubles sell for at least $75 a metric ton.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Minnesota

4.0060,

COMBUSTION OF CROP RESIDUES TO DRY CORN

R.V. Morey, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *St. Paul, Minnesota* 55101 (3090-20591-030-C)

OBJECTIVE: Characterize crop residues as fuel sources for drying corn, develop design criteria for combustors of downdraft or crossdraft design, and evaluate methods for mixing combustion gases with ambient air so that the mixture will not damage nor contaminate grain.

APPROACH: Collect corn residue samples including cobs, stalks and leaves, determine their heat values by bomb calorimetry & ash content by ASTM procedures. Determine storage characteristics for various moisture contents, temperatures & storage periods. Develop a laboratory scale combustor to evaluate downdraft & crossdraft combustion having output about 100,000-200,000 BTU/hr. Vary grate configuration, air introduction methods & residue feeding mechanisms & evaluate heat release/unit grate area, conbustion efficiency, & exhaust gas temperature & composition. Evaluate methods & devides for mixing combustor exhaust with ambient air to provide desired drying temperature. Analyze mixture composition & evaluate corn samples exposed to the mixture for undesirable odors or discoloration as indicators and problems requiring further analysis.

SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Illinois - Indiana - Ohio Area

4.0061,

REDUCTION OF NON-RENEWABLE ENERGY CONSUMPTION FOR GRAIN DRYING

R.V. Morey, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *St. Paul, Minnesota* 55101 (MIN-12-023)

OBJECTIVE: Evaluate energy utilization of combination high-temperature, low-temperature drying systems for shelled corn. Develop recommendations for design and management of low-temperature, ambient-air drying systems for corn and other grains under Minnesota weather conditions. Evaluate the potential for using crop residues to supply heat energy for high-temperature, high-speed grain drying.

APPROACH: Combination high-temperature, low-temperature drying will be evaluated under field scale conditions. Propane and electrical energy requirements will be monitored. Computer simulation will be used in evaluating the performance of low-temperature, ambient-air drying systems. Design and management recommendations will be based on these results. Evaluation of the potential for using crop residues will include feasibility analysis, evaluation of existing devices for energy recovery from residues and demonstration scale research on crop residue fired drying system.

PROGRESS: Drying treatments involving high-temperature drying at 95 degrees C or 150 degrees C followed by in-storage cooling and low-temperature drying at 0.6 and 1.1 m 3/min-t were carried out during 1978 harvest season. Conventional high-temperature drying to 15-1/2% and dryeration also were evaluated. Results were consistent with previous years' results with propane requirements for combination drying reduced by 50% to 80% compared to

conventional high-temperature drying, depending on initial and final moisture contents. Electrical energy requirements were increased due to low-temperature component of drying. Significant variation from year to year in energy requirement per unit of water removed for low-temperature drying was observed. In all cases total energy for the low-temperature phase of drying was less than total energy for comparable moisture removal by conventional high-temperature methods. Grain quality was good with significant reduction in susceptibility to breakage. Operating procedures requiring minimum control equipment and observtion were developed using computer simulation. Continuous operation of fan was found to be superior to management techniques which involved shutting off fan based on temperature, relative humidity or time-clock. Low-temperature, natural-air wheat drying model was developed. Natural-air drying experiment with wheat was carried out in Summer 1978 to gain field experience and data for checking model.
SUPPORTED BY Minnesota State Government

4.0062,
INTERPRETATION OF PROPERTIES OF PRINCIPAL MINNESOTA SOIL SERIES.
R.H. Rust, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Soil Science, *St. Paul, Minnesota* 55101 (MIN-25-018)
OBJECTIVE: Develop, from available data, interpretive classifications of land for a variety of uses - agriculture, forestry, residential and industrial development, recreation, and transportation.
APPROACH: The principal effort would be in development of information retrieval and display systems-tabular and graphic - or original and derived data correlated with the specific interpretation. Means or methods would be developed to provide 'instant' or 'on line' interpretations at several generalizations so as to serve the needs of the individual developer or manager, as well as the large scale regional planner. The recent developments in computer 'visigraphics' would be investigated for application.
PROGRESS: Certain guidelines and interpretations of soil landscapes for agricultural and non-agricultural land use were developed for the generalized soil maps. The initial effort was concentrated in the 7-county metropolitan area. Interpretations were made for 15 kinds of land use. In cooperation with the Agricultural Research Service a preliminary study and analysis of soils and landscapes in 4 counties was made to ascertain the possible area from which corn residue removal for bioenergy might be feasible. Training sessions have been conducted to acquaint agricultural agents, assessors, soil conservationists and others in using a soil productivity estimate for assisting in the process of rural land assessment. Twelve field locations were selected in western counties of the state for monitoring soil moisture and plant condition in connection with aircraft and LANDSAT imagery. A field study was begun in Clay County to delineate saline affected soils using color infra-red imagery at the scale of the detailed soil survey (1:20,000).
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Minnesota

4.0063,
BIO-GAS PRODUCTION FROM ALLIGATOR WEEDS
A. Latif, Alcorn State University, Graduate School, Dept. of Biology, *Lorman, Mississippi* 39096 (NSG 8036)
Bio-gas and methane production from the microbial anaerobic decomposition of alligator weeds (Alternanthera philoxerides) (Mart.) Griesb., was investigated. These experiments demonstrated the ability of alligator weeds to produce an average of 7.5 ml of methane gas per gram of wet plant weight. The study revealed that sample preparation, light intensity, addition of reducing agents and other additives had no significant effect on bio-gas and/or methane production. Increasing initial pH of the liquid content of the fermentation unit increased bio-gas and methane production significantly. Raising incubation temperature from 24 degrees C to 35 degrees C, increased bio-gas and methane production but reduced the time lag between the production of biogas and production of methane gas. After the gas production ceased, the accumulated sludge in each fermentation unit was throughly shaken and the liquid content was used for bacterial enumeration, isolation and characterization. This work is still in progress. The result of this study will be reported in the annual report.
SUPPORTED BY U.S. National Aeronautics & Space Admin., National Space Technology Lab.

4.0064,
EFFICIENT PRODUCTION OF METHANE FROM WATER HYACINTH JUICES USING ANAEROBIC DIGESTION FILTERS
B.C. Wolverton, U.S. National Aeronautics & Space Admin., National Space Technology Lab., *Biloxi, Mississippi* 39529 (L822C-054)
OBJECTIVE: To develop an efficient method for producing energy from plant juices extracted from water hyacinth (Eichhornia crassipes) biomass harvested from wastewater aquaculture treatment systems.
APPROACH: Laboratory experiments will be conducted to determine optimum size, configuration, microbial surface, digestion time, etc. of anaerobic digestion filters to provide biogas containing a high percentage of methane from plant juices.
PROGRESS: Project initiated.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Robert S. Kerr Environmental Research Lab.

4.0065,
EQUIPMENT & STRUCTURES FOR ON-FARM ENERGY PRODUCTION & UTILIZATION FROM AGRICULTURAL WASTES & RESIDUES
J.R. Fischer, University of Missouri, Columbia Campus, U.S. Dept. of Agriculture Agricultural Research, Bioengineering Research, *Agricultural Eng. Bldg. T 12, Columbia, Missouri* 65201 (3402-20400-006)
OBJECTIVE: Determine physical, biological and chemical relationships that occur during anaerobic digestion of agricultural residues. Develop equipment, operating technology and management procedures for on farm production of methane gas from agricultural residue, develop method whereby methane gas may be effectively utilized on the farm to replace the use of fossil fuel energy, and evaluate the recycling of digester effluent as a source of fertilizer.
APPROACH: Laboratory studies will be conducted using six, 20 liter model digester systems to evaluate agitation requirements, effects of antibiotics, and the effect of rations on anaerobic digestion of swine manure for biogas production. A 420 liter prototype digester will be used to study the effect of loading rate on biogas production. Also this unit will be used in a comparison study of mixed mesophillic digestion with plug flow digestion. The farm size digester will continue to be used to: define management problems, vertify reliability of equipment and the automatic control system, maximize gas production from recycled solids and conservation of energy, and evaluate energy and effluent utilization.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Great Plains Area

4.0066,
ANIMAL WASTE STABILIZATION
J.C. Boyd, Montana State University, Agricultural Experiment Station, Dept. of Animal & Range Science, *Bozeman, Montana* 59715 (MONB00181)
OBJECTIVE: Determine factors affecting the minimum aerobic treatment which will stabilize odors and retain maximum nutrient content in animal wastes. Study factors affecting the establishment of a dominant micro flora and the effectiveness of such a microflora in odor control and nutrient recovery. Study alternate uses for odor stablized animal waste other than return to agricultural land.
APPROACH: Laboratory and pilot plant studies on oxygen level, pH, and nutrient recovery in an odor stabilization process and odor stabilized products.
PROGRESS: As indicated in previous reports, ammonia nitrogen in aminal waste (a) makes up some 30 to 40 percent of the total nitrogen, (b) is not utilized by non-rumin animals, (c) is not efficiently converted to bacterial cells, (d) at certain concentrations may be inhibitary to bacterial growth, and (e) is lost in drying of the waste material. The principle objective of this year's work has been investigation of ways to more fully utilize this nitrogen fraction. Much of the work has been done in cooperation with Dr. Robbins of the Chemistry Department. Three research applications from grants of financial aid were proposed and one entitled 'Biological & Bio-chemical Techniques Applied to the Conversion of Waste Material to Useful Products' was funded in the Chemistry Department. Chemical investigation on methodology for analysis of animal waste materials for ammonia levels, and for fermentable carbohydrate levels have been reported under Project 250. Stripping of ammonia nitrogen from the animal waste material has been successful with about 90 percent recovery. Adding of additional fermentable carbohydrate to encourage greater bacterial utilization of the ammonia nitrogen resulted in some increase in methane production when glucose was used. Use of chemically treated straw to provide the additional fermentable carbohydrates was attempted but could not be adequately evaluated due to mechanical problems in handling the straw.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Montana

4.0067,
AMMONIA PRODUCTION FROM ANIMAL WASTE
J.E. Robbins, Montana State University, Agricultural Experiment Station, Dept. of Chemistry, *Bozeman, Montana* 59715 (MONB00250)
OBJECTIVE: Establish a simple fast, and sensitive method for quantitative assay of ammonia in fecal material extracts. Devise an efficient method of releasing and collecting ammonia from fecal matter. Explore enzymatic methods for increasing the ammonia yield from F.M. Determination of the optimum N/C ratio in F.M. for maximum methane yield from anaerobic fermentation. Establish a pilot plant scale production of ammonia.
APPROACH: The approach for objective 1 is drawn from enzymatic catalyzed reactions in ammonia metabolism. A dehydrogenase spectrophotometric method will be used. Objective 2 will be based on acid-base equilibria. This should allow solvation or dissolution of ammonia gas. Objective 3 will entail studies using the enzymes urease, uricase and others to release additional ammonia. Objective 4 would involve removing various amounts of nitrogen (N) from F.M. and subsequent fermentation of the F.M. monitoring the methane yield. Objective 5 is dependent upon 1-4.
PROGRESS: Three important objectives were met in this study. A simple, rapid and precise analysis for ammonium in fecal waste samples was established. (See Robbins, J.E. and Weber, S.C. 1977, An Enzymic Assay for Ammonia in Waste Matter. Agric. And Food Chem. 25:688-690). This method saves considerable time by eliminating the necessity of distillation prior to analysis. Secondly, the appropriate conditions to provide 95 to 100% stripping capability were established. The conditions necessary to remove ammonia from cattle waste were reactor temperatures of 40 to 50 degrees C, a pH range of 9 to 10 and the ability to flush the reactor with air. Thirdly, a scrubber was designed which by analyses was shown to trap between 85 and 93% of the ammonia removed. The scrubber consisted of two cylindrical glass tanks containing a manifold tube, coarse sand and a phosphoric acid solution of pH 1. The tubing carried ammonia containing air from the reactor to the bottom of one cylinder, releasing some air, via the manifold and similarly then to the second cylinder and exhausted. The two cylinders were cooled by tap water circulated through plastic tubing wrapped around each cylinder.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Montana

4.0068,
ECONOMICS OF NEW TECHNOLOGIES IN LIVESTOCK PRODUCTION AND MARKETING
V.L. Harrison, U.S. Dept. of Agriculture, Economics & Statistics Service, Commodity Economics Div., Meat Animals Program Area, *Clay Center, Nebraska* 68933 (CE-06-056-31-03)
OBJECTIVE: Identify and evaluate resources and technologies of potential use in meat animal production; develop analytical production relationships to optimize meat production per unit of resource use for the major segments of meat animal agriculture in the United States; identify and establish relative priorities of research needs in meat animal production, processing and marketing. Simulate the long-range effects at both the firm and industry level of alternative meat animal production technologies and management strategies under various assumptions concerning consumer demand, marketing and distribution strategies, and agricultural policies.
APPROACH: Construct models to study economic impacts of various technologies in livestock production being developed at the U.S. Meat Animal Research Center; results will provide input coefficients for the analysis. Emphasize new technologies and practices in livestock production which are expected to have an unprecedented impact on agricultural productivity. Study short and long term impacts on individual producers, the livestock industry, the processing distribution sector, and consumers.
PROGRESS: Considerable time was spent advising scientists and project leaders at U.S. Meat Animal Research Center on economic components of their

research. Provided counsel to Veterinary Health Officer on economics of various measures of eliminating or controlling diseases and parasites in livestock; to Research Engineer on economics of waste management and treatment of animal waste for production of methane, animal feed, and fertilizer; to animal geneticists on economic importance of various traits for selection in breeding livestock; and to management systems research leaders on design of experiments for applying new technologies in livestock production.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Commodity Economics Div.

4.0069,
ANAEROBIC FERMENTATION OF LIVESTOCK AND CROP RESIDUES
A.G. Hashimoto, U.S. Dept. of Agriculture, Agricultural Research, U.S. Meat Animal Research Center, *P.O. Box 166, Clay Center, Nebraska* 68933 (3415-20400-005)
OBJECTIVE: Determine feasibility of anaerobic fermentation to recover methane, protein and plant nutrients from agricultural residues.
APPROACH: The work plan is divided into four tasks: Parametric testing; biomass recovery; biomass nutritive evaluation; and scale-up and economic evaluation. Parametric testing evaluates the effects of operating parameters (mixing, temperature, residence time and loading rate) on biomass and methane production. Biomass Recovery will be by centrifugation and lower cost solids recovery systems. Biomass nutritive evaluation consists of the chemical composition of the biomass and in vitro and in vivo digestibility. Capital and operating costs of the overall system will be evaluated.
PROGRESS: The pilot scale fermentor is 5.7 m with working volume between 5.1 to 5.4 m . Fermentation was started by adding fresh beef manure to previously heated tap water and maintaining the pH above 7. Gas production increased dramatically within nine days after start up, demonstrating the relative ease in initiating anaerobic fermentation of livestock manures. The fermentor was operated at 55 degrees C; 20, 12, 6 and 3 days' retention times; and loading ra es of 3.4, 5.2, 11.4 and 22 kg VS/m / day. The results showed that the total solids and COD reduction decreased as the retention time decreased; the fixed solids and total nitrogen were not lost during fermentation; and the total gas and methane production rates increased as the retention time decreased. Feeding trials using dried centrifuge cake showed that the digestibility of dry matter, organic matter, and nitrogen tended to decrease slightly as the amount of cake in the ration increased. Preliminary results of the feeding trial using fermentor effluent mixed with corn and hay showed that the fermentor effluent is utilized as well as soybean protein.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mid Great Plains Area

4.0070,
IMPACT OF PUBLIC POLICIES ON NEBRASKA'S AGRICULTURAL AND RURAL DEVELOPMENT
J.G. Kendrick, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Agricultural Economics, *Lincoln, Nebraska* 68508 (NEB-10-064)
OBJECTIVE: Develop simulation models that will represent the major types of agricultural production units in 1970's. Utilize the models in simulations of the impact of selected present and alternative public policies upon agricultural Micro organization production and incomes, and Macro production and income including the distribution of that production and income. Advise individual farmers, ranchers and other citizens concerning optimal strategies under existing public policies. Advise policy makers as to the impact of present and alternative public policies upon Nebraska's economy. Ascertain which public policies are most likely to be politically acceptable to citizens.
AF PROACH: Detailed linear programming models have been developed and these matrices will be expanded to include various size, income and cropping-livestock operations in Nebraska. Expansion will be accomplished by utilizing current agricultural census data, results of the NEBFARM project, the experience of the farm management extension staff and research results from various production economic projects. The political acceptability of selected policies will be evaluated by field surveys of Nebraska citizens.
PROGRESS: The past year's research was broadly based in areas where Nebraska citizens were making policy decisions. The publications listed below are illustrative of the scope of the work of this project. The grain alcohol study found that ethanol might be used in motor fuel if a subsidy of 90/gallon were offered. Circular on ballot issues explained consequences of 'Yes' and 'No' votes to help voters decide how to vote. Information was also published in Nebraska Farmer. Explanation of 1978 wheat and feed grains programs; procedure for farmers to use in deciding whether to participate. Compilation of Nebraska data from 1977 Census of Governments, distributed to State Senators, other leaders. Analysis of situation and projection as to population, food energy and other resources, and discussion of policy alternatives and institutional change. Need for improved communication between research and extension workers and for better criteria for evaluation of performance. Abandonment of branch line railroads and larger trucks and farm implements are causing deterioration of rural roads and bridges and creation of hazardous conditions. (Text Truncated - Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Nebraska

4.0071,
SIGNIFICANCE, STUDY AND USE OF ENZYMES IN THE FOOD INDUSTRY
K.M. Shahani, University of Nebraska, Lincoln Campus, Agricultural Experiment Station, Dept. of Food Science & Technology, *Lincoln, Nebraska* 68508 (NEB-16-026)
OBJECTIVE: Study possible uses of various enzymes in modifying the physico-chemical and flavor characteristics of foods.
APPROACH: There exist considerable potentials for the development of enzymic applications to improve the present food processes. Studies will be made to determine the use of lipases and proteases to accelerate cheese ripening; lactase to hydrolyze lactose in whey; glucose oxidase to desaccharify eggs; and deaminases to deaminate nitrosamines in meat. Also, the effects of enzymic processes upon the nutritional qualities of foods will be studied.
PROGRESS: Lactase immobilized on diazotized agarose was used to hydrolyze lactose in whey and milk. The immobilized lactase was partially inactivated while in contact with milk and whey. However, the immobilized lactase hydrolyzed lactose in pure solution as well as in whey ultrafiltrate (permeate) for a period of 36 to 48 hr without loss of much activity. These results indicated that whey and milk proteins, presumably, were responsible for inactivating the enzyme. Enzymically and microbially modified whey and whey permeate were used successfully to ferment lactose into alcohol for use in the manufacture of gasohol (90% gas plus 10% alcohol). Efforts are underway to develop an enzymic process of alcohol fermentation, using whey and grain mixtures. Whey proteins in liquid whey, commercial whey protein concentrate and those isolated by heat precipitation were hydrolyzed by pepsin, trypsin and papain. Hydrolytic patterns of whey proteins, obtained with immobilized and soluble papain, appear to be fairly similar, indicating that immobilization did not alter the hydrolytic characteristics of papain.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Nebraska

4.0072,
COMPETITION FOR RURAL RESOURCES
D. Morris, University System of New Hampshire, University of New Hampshire, Inst. of Natural & Environmental Resources, *Pettee Hall, Durham, New Hampshire* 03824 (NRE-43-322-33-01)
OBJECTIVE: Develop functional relationships for the supply of land to agriculture and among competing uses, relating land availability to commodity prices, commodity policies, resource policies, non-agricultural competing uses and other significant variables. Relate agricultural land availability to agricultural capacity and develop linkages between policy variables and the amount of land use and agricultural capacity.
APPROACH: Develop a system to account for land use changes over time as between agricultural uses, abandonment, reclamation, by irrigation or drainage, recreation, forestry, urbanization and surface mining. Use economic theory, models and statistical techniques to estimate functions relating land use for various purposes to explanatory variables. Using a regional definition system consistent with other projects and program areas of the division and of the Commodity Economics Division, estimate land supply among competing uses by region. In cooperation with other Division, intergrate land supply estimates with estimates of input supplies, yield projections and other measures of productivity to the capacity of agriculture.
PROGRESS: The year provided evaluations of the nature and extent of competition for rural resources from several sources. The actual withdrawal of land and water from agricultural production for surface mining will have rather minor consequences to agricultural output potentials. Preliminary analyses reveal the biomass energy could be competitive with returns from nonirrigated agricultural production at cost of about $3 per 10 BTU's. Without significantly increased costs of alternative energy sources, land and water use for biomass production are not economic at the present. Should biomass production become feasible, sizable amounts of land would be required. Research on the effects of urbanization and population growth on agriculture across the U.S. has revealed that each one percent increase in population density in urban areas is associated with a 1.05% increase in farmland values. Examination of the factors associated with groundwater irrigation development in the Central and Southern Plains have not reached any conclusions. The effects of energy prices and availabilities on these agricultural production systems are significant, however.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Natural Resource Economics Div.

4.0073,
PYROLYSIS OF AGRICULTURAL RESIDUES AND FEEDLOT WASTES IN A REACTIVE STEAM ATMOSPHERE
M.J. Antal, Princeton University, School of Engineering & Applied Sciences, Dept. of Aerospace & Mechanical Sciences, *Box 430, Princeton, New Jersey* 08540 (B624B-538)
OBJECTIVE: Investigate basic kinetics of the pyrolysis of wastes.
APPROACH: Through bench-scale experiments collect data to identify and mathematically model pyrolysis kinetic utilizing various organic wastes as feedstocks.
PROGRESS: Interim report on results.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

4.0074,
ETHANOL FOR FUEL - PRODUCTION BY ZYMOMANS
T. Chase, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, Dept. of Biochemistry & Microbiology, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (NJ01503)
OBJECTIVE: Simplify conversion of agricultural biomass (starch) to ethanol, a liquid transportation fuel, by constructing a hybrid bacterium, Zymomonae, able to degrade the starch and ferment it continuously to ethanol at a high temperature.
APPROACH: Theromotolerant Zymomonas strains will be selected. Fermentation conditions with starch-derived glucose syrup as substrate will be optimized. Levels of enzymes of the fermentation pathway will be determined. Zymomonas cells will be immobilized for continuous fermentation. Starch degrading pseudomonads will be hybridized with Zymomonas by conjugation, transformation with isolated DNA, or transformation via plasmid intermediates. Hybrids will be characterized with respect to stability, ethanol yields and rate of starch degradation.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New Jersey

4.0075,
ENZYMATIC DEGRADATION OF POLYMERS PRODUCED BY PLANT AND FUNGAL CELLS
D. Eveleigh, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, Dept. of Biochemistry & Microbiology, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (NJ00515)
OBJECTIVE: Produce catabolite repression resistant hypercellulase mutants of T. viride and clarify the mechanisms controlling the synthesis of cellulase.
APPROACH: This project is directed to the microbial conversion of waste agricultural materials into useful by-products. Waste cellulosics (corn stalks, etc.) can be degraded to gluscose enzymaticaly using microbial enzymes, and this product fermented to ethanol - a useful energy sparing material. Analogously, the waste agricultural components can be up-graded to high quality single cell protein by successive action of microbial enzymes and growth of food yeasts.
PROGRESS: Ethanol is a prime candidate as an alternate transportable fuel of the future. It may be

obtained by enzymatic conversion of wood substrates by cellulose to glucose, with fermentation of the latter to ethanol. A major cost factor is the production of cellulase. We have obtained hyper cellulolytic strains of Trichoderma reesei using selective procedures, based on the use of cellulose and p-nitrophenyl glucoside substrates in the presence of catabolite repressors (glucose/glycerol). One mutant, RUT-NG14, has been examined in detail. It yields 15 filter paper cellulase units/ml in large scale fermentation; a 15-fold increase over the original strain QM6a. Cellulase synthesis is considerably repressed when RUT-NG14 is grown in the presence of glycerol. Fully catabolite-repression-resistant strains are being sought.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New Jersey

4.0076,

HIGH TEMPERATURE STABILIZATION AND MOISTURE REMOVAL FROM ANIMAL WASTES FOR BY-PRODUCT RECOVERY

W.J. Jewell, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123584)

OBJECTIVE: An ideal animal waste treatment and residue recovery system would convert obnoxious wet animal wastes to an odorless, stabilized, pathogen-free material with moisture content less than 40% in a simple process without addition of large amounts of energy. The goals of this study will be to determine the feasibility of developing such a process and to build a bench scale pilot unit process to demonstrate its potential.

APPROACH: The basic steps that will be utilized to meet the project goals are: Determination of kinetics of organic carbon decomposition and oxygen transfer limitations in semi-solid animal wastes created by combining the treated and dried animal wastes with the wet raw wastes; determine the heat released during aerobic stabilization and identify means of conserving the energy to achieve autoheating of the organics; measure the rate of moisture removal from autoheated animal wastes; combine the above into a simple single unit pilot plant that would achieve high rate organic stabilization and simultaneous moisture removal; and determine, at temperatures of 60 to 70 C, autoheating requirements to produce pathogen destruction and maximum microbial production of protein.

PROGRESS: Aerobic oxidation of organics by microorganisms results in the release of energy in the form of heat. This project is being conducted to determine the feasibility of using this energy to stabilize animal wastes, parteurize them, and then use the remaining energy for moisture removal. For similicity, the process under development is referred to as the biodryer. Laboratory testing to define the fundamentals of high temperature semi-solid aerobic decomposition of dairy wastes has been completed. This information provided the basis for a design and operation of a small (20 liters per day feed rate) pilot reactor. Successful operation of the small pilot unit has led to the design and operation of a large pilot biodryer (1000 liters per day feed rate). Activities on the project have included asessment of the nutritional characteristics for consideration of refeeding the product, survey of pathogen survival, and a computer simulation of the process.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New York

4.0077,

ANAEROBIC FERMENTATION OF AGRICULTURAL WASTES - POTENTIAL FOR IMPROVEMENT AND IMPLEMENTATION

W.J. Jewell, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123360)

OBJECTIVE: Determine the potential for optimizing technology related to anaerobic fermentation of agricultural wastes; identify fermentor designs capable of more rapid or more efficient recovery of energy containing by-products of gas, nutrients and solid residues, and to demonstrate the feasibility of improved fermentors using small laboratory models followed by large scale pilot plants. Studies will be conducted with dairy cow wastes.

APPROACH: This study will be divided into 3 major efforts -identification of improved fermentor designs using small scale laboratory models, definition of optimized fermentor designs, and demonstration of new process feasibility in large scale pilot plants. Two general concepts will guide the development of future optimized anaerobic fermentation technology: Simplistic operation involving minimal manpower and the elimination of the waste by production of useful energy-containing by-products. The focus will be on the transformation of a 'waste' into useable but currently unrecovered energy-containing by-products. The Cornell study has identified two unique anaerobic fermentation system designs: One could be capable of operation with the simplest of demands on the farm; whereas a complex unit may accomplish stabilization, methane production, liquid-solids separation and pathogen destruction in one unit operation.

PROGRESS: This large study is in the last year of a three year effort. It has had an overall goal of developing and improving economic and technical factors which would lead to widespread implementation of anaerobic fermentation to produce biogas on small-scalle agricultural operations. Data is now being obtained from simplified pilot and full-scale fermentors operated on dairy cow manure. The following reactor types have been constructed and are operating: (1) Pilot scale randomly fed and mixed, three-cow residue handling capacity when operated at a 30-day NRT; (2) Pilot scale plug flow reactor, three-cow residue handling capacity when operated at a 30-day HRT; (3) Full-scale plug flow reactor, 65-cow residue handling capacity when operated at a 10-day HRT; and (4) Full-scale conventional completely mixed control, same residue handling capacity as the full-scale plug fermentor. The lower limits on design criteria, construction materials, and operation are being defined with the above reactors. (Text Truncated - Exceeds Capacity)

SUPPORTED BY New York State Government

4.0078,

AUTOHEATED AEROBIC THERMOPHILIC DIGESTION WITH AIR AERATION

W.J. Jewell, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123331)

OBJECTIVE: Determine the practical feasibility of treating municipal primary and secondary sludges with autoheated theromophilic digestion using air aeration. This will be accomplished with an existing full scale commercially available process identified the 'Licom Sys'em.' Relate the organic loading rates of sludges to autoheating capability, determine effects of autoheated aerobic treatment of sludge on stabilization (rates and quantity) and dewaterability of the sludge, and determine aeration and oxygen transfer requirements for autoheating.

APPROACH: A full scale thermophilic digestion system has been demonstrated to be capable of autoheating cow manure slurries of 95% moisture at 63 C at Cornell University. This system is completely isolated with separate feed storage tanks, two stage completely mixed 1000 ft reactors, automatic continuous feed pumps and large effluent storage tanks. The majority of information will be developed with primary sewage sludge with combinations of primary and secondary sludge tested in the later phases. All full scale testing with primary sludge will be completed in one year. The sludge will be trucked into this facility from a nearby town. Small scale laboratory reactors will be operated simultaneously with the large scale units to obtain detailed information on substrate removal kinetics and impact on other sludge characteristics.

PROGRESS: Digestion of waste organics slurries with a simple high temperature aerobic biological treatment system offers advantages such as high rate of oxidation and pathogen destruction. Conservation of the heat of oxidation to achieve autoheating to temperatures exceeding 43 degrees C have been difficult to achieve with sewage sludge except with highly concentrated organics of by use of pure oxygen. This two-year study demonstrated with a full scale system (28.4 m 3) that simple self-aspirating aerators could achieve high oxygen transfer efficiencies and thus autoheat to high temperatures using ambient fair. Continuous feed operation of a one-stage digestion system on a combination of primary and waste activates sludge (3 to 6% total solids) resulted in autoheating to temperatures exceeding 45 degree C for an operational period exceeding 1.5 years. This period included air temperatures of minus 20 degrees C and feed sludge temperatures as low as minus 2 degrees C. (Text Truncated - Exceeds Capacity)

SUPPORTED BY New York State Government

4.0079,

EQUIPMENT AND PROCESSING TECHNIQUES FOR FOOD PRODUCTS

W.K. Jordan, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Food Science, *Ithaca, New York* 14850 (NYC-143302)

OBJECTIVE: Determine the influence of equipment and processing techniques on the efficiency of food plant operations and on the quality of the foods processed.

APPROACH: Complete a study on energy use and conservation in dairy plants. Evaluate the properties of frozen desserts as influenced by formulation and type of freezing equipment. Study anaerobic digestion of cheese whey.

PROGRESS: A study of the feasibility of anaerobic digestion of waste whey for methane generation was completed. Bench scale anaerobic reactors were loaded daily at low, medium and high COD and maintained at three selected temperatures in the mesophilic and thermophilic ranges. An economic analysis comparing anaerobic digestion with other means of whey disposal indicated it to be the most cost effective for projected commercial-sized cheese plants.

SUPPORTED BY New York State Government

4.0080,

ENERGY IN ANIMAL MANURES

A.T. Sobel, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123422)

OBJECTIVE: Investigate the utilization of biologically released heat from animal manures for on-farm applications. Specifically investigate the effect of heat energy released from in-barn stored manure on the quality of the environment within the barn.

APPROACH: Agricultural by-products, animal manure being a specific example, represent a considerable quantity of energy. These by-products represent to the Agricultural Engineer a challenge to make use of this energy to supplement our dwingling and increasingly more costly energy sources. The purpose of this research project is to take an overall look at energy from animal manures with specific emphasis on utilizing biologically produced heat and to provide some basic concepts into the magnitude of heat energy available, the conditions favorable to its release, and potential means of utilizing this energy. A comparison of the various forms of energy will be made to determine the efficiencies of energy utilization systems.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New York

4.0081,

ALCOHOL PRODUCTION FROM AGRICULTURAL BY-PRODUCTS

W. Vergara, Cornell University, Ithaca Campus, New York State College of Agriculture & Life Science, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123343)

OBJECTIVE: Determine the feasibility of applying a high rate biological process originally developed at Cornell to agricultural residues for ethanol production. This initial feasibility study will examine the feasibility of developing a strongly attaching pure ethanol producing microbial population to small inert particles in an upflow 'expanded bed' continuous flow reactor; determine the potential of continuous removal of alcohol from the reactor; detrmine the potential of continuous removal of alchol from the reactor by vacuum distillation; measure maximum concentration of ethanol in the product gases; describe the kinetics of microbial growth and ethanol production.

APPROACH: Two small laboratory expanded bed reactors will be operated for alcohol production from sugar beet molasses. Organisms that will be examined will be from several strains of yeast (S. cerevisiae) or bacteria (Clostritium thermocellum) that have been shown to be capable of high rates of ethanol producion. The initial feasibility testing will have a duration of six months. Successful development of this application will provide necessary information to justify additional scale-up and comprehensive testing.

SUPPORTED BY New York State Government

4.0082,
THERMOPHILIC METHANE PRODUCTION FROM POULTRY WASTE
J. Shih, University of North Carolina, North Carolina State University, Agricultural Experiment Station, Dept. of Poultry Science, *Raleigh, North Carolina* 27600 (NC03605)
OBJECTIVE: Isolation and selection of a methanogenic bacterial culture in a poultry waste-based medium at thermophilic temperatures; adaptation of the methanogenic culture to a highly efficient methane producer and chemical analyses to fully characterize the wastes, the gas products, and the effluents from the reactor.
APPROACH: A number of cultures of thermophilic bacteria will be screeened to identify the strains that have the capability of producing large volumes of methane from poultry waste. Preliminary laboratory studies will be conducted to purify the strains and perfect the methane generation.
PROGRESS: Different sources of microbial flora from the natural environment were tested to initiate a bacterial culture which could digest the broiler waste to generate methane gas at thermophilic temperatures (55 degrees-60 degrees). Finally a culture which was started with an inoculum from the salt marsh was isolated and maintained in the laboratory. At 10 day retention time, 3% VS loading, and 60 degrees C. the culture produced consistently 100-150 ml gas/day/500 ml mixture. Although this is not yet a very high rate of gas production before the optimization to be carried out, this demonstrated the possibility of bioconversion of poultry waste to methane at thermophilic temperatures with an inoculation of appropriate source of microbes. Simultaneously, analytical procedures were gradually set up in the laboratory. The procedures established were the determinations of total nitrogen, microbial protein, volatile acids, and total fats. The procedures under development are the gas chromatographic analysis of the gas mixture and the determination COD value.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Carolina

4.0083,
HYDROGEN-PRODUCING BACTERIA IN ANAEROBIC WASTE TREATMENT
P.E. Holmes, North Dakota State University, Agricultural Experiment Station, Dept. of Bacteriology, *Fargo, North Dakota* 58103 (ND01811)
OBJECTIVE: Identify hydrogen-producing bacteria in anaerobic waste treatment; define parameters affecting hydrogen-producing bacteria; determine the importance of hydrogen-producing bacteria in anaerobic waste treatment.
APPROACH: In situ rates of hydrogen generation and turnover will be estimated as a function of factors known to influence waste treatment. Direct isolation and characterization of anaerobic bacteria from wastes being treated anaerobically. Ability to produce hydrogen will be assessed, using growth conditions that closely simulate the habitat of an anaerobic digester. Parametric study of pure culture isolates that will consider factors known to influence anaerobic treatment. Such parameters will include pH, temperature, substrate types and concentrations, oxygen and redox potential, organic and inorganic substances other than substrates and components of the waste.
PROGRESS: The occurrence of active hydrogen (H(2))-producing bacteria in hog waste undergoing anaeobic digestion at low temperature (4 degrees C) was found to be very low, as was the entire digestion process. None of the isolates from these digesters were found to make H(2) when selection was for strains able to grow in complex media at 4 degrees C. Since the digesters are only 1 1/2 years old and not fully adapted yet to operation at 4 degrees C, these results may change. Procedures are being developed to increase the rate of culture purification to facilitate this work.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Dakota

4.0084,
PSYCHROPHILIC ANAEROBIC WASTE TREATMENT IN NORTHERN CLIMATES
P.E. Holmes, North Dakota State University, Agricultural Experiment Station, Dept. of Bacteriology, *Fargo, North Dakota* 58103 (ND05080)
OBJECTIVE: Seasonal effects on occurrence and activity of psychrophilic and psychrototrophic bacteria in anaerobic waste lagoons; parameters of growth and activity of psychrophilic and psychrotrophic anaerobic bacteria; study laboratory scale low temperature anaerobic digesters; determine effectiveness of seeding conventional lagoon models with psychrophilic and psychrotrophic anaerobic bacteria in relation to operating temperature; assess potential for methane recovery from low temperature anaerobic lagoons.
APPROACH: Lagoon samples are cultured directly on selective and non-selective media at various temperatures to assess numbers and types of bacteria and correlated with physical-chemical parameters of the lagoon. The Hungate anaerobic technique used; isolates with temperature optima below 20 C will be further characterized; laboratory scale digesters will be discontinuously fed typical lagoon feed and operated at various temperatures; seeding studies will monitor methanogenesis, waste turnover and seed growth; zero-time rates of methanogenesis will be used to assess potential for methane production and digestion rates.
PROGRESS: Temperature optima for anaerobic digestion of hog waste in digesters operated continuously at 4 degrees, 15 degrees and 25 degrees C was found to be dependent on digester age, retention time and temperature. The complex interaction results in part from the fact that the digesters operated at 4 degrees C have not yet adapted to that temperature and are not in steady state. Cultures of bacteria with temperature optima near 20 degrees C were isolated on complex media from a digester operated 1 1/2 years at 4 degrees C. They are unable to grow above approximately 30 degrees C and resemble members of the genus Bifidobacterium. No colonies appeared in the same media at 4 degrees when inoculated from similar digesters operated at 25 degrees C. These results indicate temperature adaptation of the 4 degrees C digesters may be occurring.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Dakota

4.0085,
BIOMASS UTILIZATION AS AN ENERGY SOURCE
J.A. Lindley, North Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fargo, North Dakota* 58103 (ND01438)
OBJECTIVE: Evaluate systems for collecting residue from field crops. Evaluate systems for densification of biomass. Evaluate systems for the direct combustion and gasification of biomass. Determine the economics and energy balance of collecting and utilizing biomass. Review availability of biomass residue and impact of removal in North Dakota.
APPROACH: Various methods for collecting sunflower residue will be tried. Evaluate successful methods in terms of time, energy and residue collection efficiencies. Evaluate parameters affecting briquetting. Review potential of other methods of densification. Review combustion process and select appropriate technology for direct combustion of biomass. May design and construct new system. Determine optimum biomass form and evaluate combustion of biomass as a method or providing on-farm energy. Determine the economic of the various steps from residue removal to energy utilization. Review literature and data from agronomy and soils to predict quantities of residue produced and available for use as an energy source.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Dakota

4.0086,
COMPETITION FOR RURAL RESOURCES
W. McMartin, North Dakota State University, U.S. Dept. of Agriculture Natural Resources Economics Div., *Fargo, North Dakota* 58103 (NRE-43-322-38-01)
OBJECTIVE: Develop functional relationships for the supply of land to agriculture and among competing uses, relating land availability to commodity prices, commodity policies, resource policies, non-agricultural competing uses and other significant variables. Relate agricultural land availability to agricultural capacity and develop linkages between policy variables and the amount of land used and agricultural capacity.
APPROACH: Develop a system to account for land use changes over time as between agricultural uses, abandonment, reclamation, by irrigation or drainage, recreation, forestry, urbanization and surface mining. Use economic theory, models and statistical techniques to estimate functions relating land use for various purposes to explanatory variables. Using a regional definition system consistent with other projects and progress areas of the Division and of the Commodity Economic Division, estimate land supply among competing uses by region. In cooperation with other Divisions, integrate land supply estimates with estimates of input supplies, yield projections and other measures of productivity to the capacity of agriculture.
PROGRESS: The year provided evaluations of the nature and extent of competition for rural resources from several sources. The actual withdrawal of land and water from agricultural production for surface mining will have rather minor consequences to agricultural output potentials. Preliminary analyses reveal the biomass energy could be competitive with returns from non- irrigated agricultural production at a cost of about $3 per 10 BTU's. Without significantly increased costs of alternative energy sources, land and water use for biomass production are not economic at the present. Should biomass production become feasible, sizable amounts of agriculture across the U.S. has revealed that each one precent increase in population density in urban areas is associated with a 1.05% increase in farmland values. Examination of the factors associated with groundwater irrigation development in the Central and southern Plains have not reached any conclusions. The effects of energy prices and availabilities on these agricultural production systems are significant, however. In studies of land conversion potentials in the southeast, it is revealed that topography, soil type, and fertility are important physical characteristics affecting land use.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Natural Resource Economics Div.

4.0087,
UTILIZATION OF WASTE FROM VEGETABLES PROCESSING PLANTS
J.R. Geisman, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00636)
OBJECTIVE: Evaluate compaction and drying methods for reducing sludge volume produced in spent brine recycling; methods for reducing water volume for freshing salt stock cucumbers, dehydration techniques for recovering by-products from tomato processing; and develop ways for using solid waste from cabbage processing.
APPROACH: Studies will be done in commercial processing plants and the laboratory. Wastes will be collected and subjected to compaction, separation, and extraction of the various components by dehydration, reverse osmosis, partial pressure, combustion and chemical treatments as applicable. Emphasis will be placed upon the development of usable products and energy sources and the efficiency of the procedures required to recover such products from the plant wastes. Solar energy sources for recovery will be tested.
PROGRESS: Spent curing brine was recycled using the pH adjustment method and applied to the eight batch of cucumbers. After curing, these cucumbers were evaluated for quality with no deleterious effect. When compared to a lot cured in fresh brine, less bloating resulted from recycling. Another lot was treated by pH adjustment with the addition of 6 ppm of an anionic polyelectrolyte with resultant highly acceptable quality. The polyelectrolyte treatment could serve as a management tool. If cucumbers were being received by the plant faster than brine was being recycled then the addition of polyelectrolyte would be warranted. If this were not the case, then management could decide whether to apply this treatment or utilize the 48 hour period in scheduling brine recycling. Several thermophilic organisms were screened for their ability to rapidly convert cellulose to available carbohydrates and upgrade protein content. Organisms which gave favorable results would be applied to cabbage waste to rapidly degrade and convert it for possible animal feed use. One organism, Sporotrichum thermophile, shows much promise and does not produce mycotoxins. Shallow pan fermentations indicate an excellent rate of conversion of celluosics to usable materials. Tomato wastes including seeds, peels and cores, after being freeze dried and ground are being evaluated as potential food additive. This material has potential for adding both high quality protein and pigments.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Ohio

4.0088,
ANIMAL WASTE MANAGEMENT CONFERENCE AND WORKSHOP
R.K. White, Ohio Agricultural Research & Development Center, Dept. of Agricultural Engineering, *Wooster, Ohio* 44691 (L770D-055)
A Livestock Waste Management Seminar and Needs Assessment Workshop will be held during the week

of May 22, 1978 in Columbus, Ohio. Three new publications will be presented and reviewed in depth at the seminar. They are: (1) Environmental Impact Resulting from Unconfined Animal Production, (2) Evaluation and Economic Analysis of Livestock Waste Management Systems (Non-NPDES) and (3) Animal Waste Utilization on Crop and Pasture Land.

The needs workshop will assess current status and future research needs and the priorities for six areas of livestock production and waste management. The needs areas will include the topics of the three new publications (above) and (4) Resource Recovery from animal wastes (feed, fuel, etc.), (5) Odor--Cause and Abatement and (6) Conservation of Energy and Nutrients in existing and new management systems. Needs assessment task groups (6 or 7 persons each) will prepare working papers for use at the Seminar and Workshop. A publication of the six needs assessments will be prepared.

Project has been awarded, seminar and workshop held as scheduled. 'Research needs assessment - Livestock Manure Management in the United States', EPA-600/2-79-179 has been published.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Robert S. Kerr Environmental Research Lab.

4.0089,

BIOGAS PRODUCTION FROM ANAEROBIC DIGESTION OF ANIMAL MANURE

H.D. Bartlett, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineenng, *201 Shields Bldg., University Park, Pennsylvania* 16802 (PEN02345)

OBJECTIVE: Determine the effects of operational and environmental factors on methane production by anaerobic digestion of animal residue at raised temperatures.

APPROACH: The 100 m anaerobic digester developed for studies on methane generation from dairy manure will be operated to determine the effects of the following on biogas production rate and quality. Recycle liquid separate from digester effluent as dilution water. Use of milking center wastewater for dilution water. Pretreat poultry manure to reduce ammonia concentration. Develop automatic controls for reduced labor. Conduct tests of biogas as combustion engine full.

PROGRESS: Modifications have been made to the manure feeding system of the 100 m digester to reduce capital cost. The outlet location has been altered to alleviate occasional clogging problems and provide for the installation of dewatering equipment to recycle the supernatant as dilution water in order to evaluate its potential for increased gas production. Temperature and pressure controls have been installed in the biogas system to provide automatic control of boiler operation and excess gas release in relation to the digester environmental needs and conditions. The digester will be operated during 1979 to evaluate the modified manure feeding, dewatering, and control system in relation to operational reliability, gas production, and labor saving. extracted with 1N NH(4)OAc, pH7. The range in E cations was from (meg/100g): 0.4 to 6.5 Ca, 0.01 to 1.3 Mg and 0.01 to 0.46 K. At 16 hours NE cations ranged from (meq/100g): 0.2 to 11.3 Ca, 0.60 to 28.0 Mg, 0.16 to 1.56 K. Absolute and relative quantities and release from soil reserves of NE basic cations may be significant to fertility requirements and seasonal patterns of nutrient uptake by plants. A field study on Hagerstown silt loam soil was initiated in Fall 1978 on effects of timing of applications, sources and rates of P and K fertilizer on alfalfa yield, chemical composition and nutrient removal and changes in soil levels of these nutrients.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Pennsylvania

4.0090,

METHANE GAS PRODUCTION FROM FARM WASTE

A.E. Branding, Pennsylvania State University, University Park Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering/Dairy & Animal Science, *201 Shields Bldg., University Park, Pennsylvania* 16802 (PEN02132)

OBJECTIVE: Determine the technical requirements and economic feasibility for methane production from farm waste.

APPROACH: Compile basic information on methane production from organic material. Design pilot plant for producing methane from farm waste, build and test the system.

PROGRESS: Initial laboratory tests established retention time, slurry concentration and expected gas production. A farm-scale digester was designed and built connected to a 50-cow dairy barn. Two systems for feeding the digester were tested. Other design modifications were also made. The 100 m two-stage anaerobic digester was operated for a total of 77 weeks. The digester has continuous gas agitation. It was maintained at 35 degrees C using some of the produced gas as fuel. Gas consumption for heating purposes varied between 25 and 70 m biogas/day (approximately 6 to 17 kW). feeding was continuous, absorbing the total amount of manure from 50 to 150 cows with an ingoing slurry concentration of 11 to 14 percent solids. The solids retention time was 5.5 to 18 days per stage; the corresponding daily digester loading was to 21 kg volatile solids (VS) per m stage volume. (The two stages had equal volume.) The daily solids conversion rate was 1.2 to 2.6 kg VS/m stage and the output was 0.75 to 0.95 m gas per kg of reduced VS. Measured daily total gas output was 105 to 200 m biogas (= heat power approximately 26 to 50 kW.) Performance tests were made using biogas as fuel for boiler, hot water heater, gasoline engine and diesel engine. Preliminary dewatering tests were made with the processed manure. Other farm-scale digesters were studied and the experience compared to Penn State results.

SUPPORTED BY Pennsylvania State Government

4.0091,

THE BIOLOGICAL PRODUCTION OF ORGANIC SOLVENTS FROM CELLULOSIC WASTES

Unknown, University of Pennsylvania, Graduate School, *203 Logan Hall, Philadelphia, Pennsylvania* 19104 (EY-76-S-02-4070)

The purpose of this project is to investigate the technical and economic constraints on a modular process for the conversion of cellulosic biomass, such as feed-lot and agricultural residues, as well as farmed energy crops, into liquid fuels and other oil-sparing chemicals (ethanol, butanol, acetone, acetate, etc). The process includes (a) an alkaline pretreatment of the cellulosic residue, (b) optimal production of a high-temperature cellulase from Thermoactinomycyes, (c) maximum saccharification of the pretreated residue to fermentable sugars, and (d) optimal ethanol production from Cl. thermocellum and butanol production from Cl. acetobutylicum. The latest results indicate an advantage for a simpler, combined high temperature saccharification and fermentation step, coupled with vaccum recovery of ethanol and solvent extraction of butanol (for minimal cost and energy use.) This process is now being intensively investigated. Alcohol fuels from this process promise to be economically competitive with oil-based fuels early in the next decade if the generally projected oil price increases occur. This project has a subcontract.

SUPPORTED BY U.S. Dept. of Energy

4.0092,

A STUDY OF THE CONVERSION OF AGRICULTURAL WASTES TO LIQUID FUELS

G.T. Felbeck, University of Rhode Island, Agricultural Experiment Station, Dept. of Food Science & Technology, *Administration Bldg., Kingston, Rhode Island* 02881 (RI00019)

OBJECTIVE: Determine by means of simulation experiments the naturally occurring conditions under which various organic materials could be converted to hydrocarbons. Apply the results of these experiments to the problem of geochemical prospecting for oil with particular emphasis on increasing the efficiency of drilling productive wells. Apply the processes developed to the conversion of agricultural waste materials to liquid fuels.

APPROACH: A matrix of organic and inorganic materials, blended to simulate marine sediment mixtures will be subjected to appropriate laboratory conditions to simulate reaction times of up to 10 years at 100 C. Reaction products will be compared with crude oil hydrocarbons to test process validity. The catalytic action of various metal compounds will be evaluated.

PROGRESS: A laboratory procedure has been developed for the generation of gaseous alkanes from various biologically-derived precursors (carbohydrates, lignins, proteins, and lipids). The process involves heating the precursor, reduced vanadium oxides, nickel sulfide, ammonia, and water in an autoclave for 15 hours at 440 degrees. The maximum yield obtained to date is about 50% on a carbon-carbon basis from cellulose. The product consists of all possible alkanes from methane to cyclopentane except for 2.2-dimethyl propane. The apparent activation energies for this reaction were calculated over the reaction temperature range of 300 to 475 degrees. At the higher temperatures (above 410 degrees) the apparent activation energy was about 51 kcal/mol, which suggests that the primary reaction was pyrolytic decomposition of cellulose. However, at the lower temperatures (below 400 degrees), the apparent activation energy was calculated to be about 22 kcal/mol, suggesting that the reaction in this range was primarily catalytic. Further support for the catalytic theory was obtained by observing that repeated use of the catalyst (up to six reuses) in the reaction produced only a slight reduction in the yield of gaseous alkanes from cellulose. Along with the gaseous products, a dark-brown hexane-soluble oil was obtained from the cellulose reaction. Fractionation of this liquid indicated that it contained alkanes, cycloalkanes aromatic compounds and a polar fraction.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Rhode Island

4.0093,

ANIMAL WASTE UTILIZATION AND TREATMENT SYSTEMS

R.O. Hegg, Clemson University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Long Hall, Clemson, South Carolina* 29631 (SC00398)

OBJECTIVE: Determine optimum harvesting, storing and processing procedures in utilizing animal wastes as feedstuffs, sources of energy and culture media and determine the response of animals to diets containing animal waste products and process by-products. Determine biological and chemical responses that occur in the soil, plant and hydrologic systems when animal wastes are applied to the major soil types of the region. Optimize waste treatment processes and management teahniques to minimize energy requirements improve utilization and enhance management efficiency, and evaluate methods of improving air and water quality in systems which recirculate waste water.

APPROACH: South Carolina approaches will include: Combining cage-layer manure and dry feeds for ensiling and recycling through steers, application of swinelagoons effluent onto pine or hardwood forest, overland flow treatment of beef feedlot runoff, land application of animal manure and analysis of animal waste lagoons for utilization of the liquids and sludges.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, South Carolina

4.0094,

ENERGY UTILIZATION AND EFFICIENCY IN AGRICULTURE

W.A. Lepori, Texas A & M University, College Station Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *College Station, Texas* 77843 (TEX06123)

OBJECTIVE: Identify present energy utilization and future needs for specific products of the Texas Agricultural Industry. Analyze methods to conserve the use of energy in present agricultural practices. Develop improved production and processing practices to reduce high energy consuming operations. Develop alternative sources of energy for agriculture.

APPROACH: Mass and Energy flow models will be developed for individual products using network theory or similar techniques. Various production scenarios will be hypothesized and tested with the models to determine potential energy conservation practices. Alternative practices will be developed and new research proposed where high energy consuming operations are found. Economic implications of the production scenarios will be investigated.

PROGRESS: A concentrated effort has been placed toward developing appropriate technology to use agricultural residues and wastes as energy for Texas farms. Cotton gin waste was collected weekly from six gins in Texas during the 1977 ginning season. Chemical and other analysis were made on each weekly sample. The average percentages for all gins on a dry basis can be summarized from an engineering use standpoint as follows: volatile matter - 85%; carbon - 42%; hydrogen - 5.4%; nitrogen - 1.4%; sulfur - 1.79%; arsenic - areas applying desiccants, .02% -areas not applying desiccants, 0.001%; oxygen and error - 34.5%. Components of the trash samples were: lint - 11%; burs - 49%; sticks -8%; and fines - 32%. Ash melting point was found to be between 1200 degrees C and 1258 degrees C. Moisture content of samples varied from 7.3% to 19.6% and gross heat value of the as received samples average 15.5 MJ/kg. Samples of sorghum residue have also been collected but analyses are not complete. Irrigated agriculture in Texas remains vulnerable to increasing fuel prices and threat of natural gas curtailments. Irrigation pumping plant efficiency

testing has continued in cooperation with TAEX to generate base data for analyzing and demonstrating conservation potential.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Texas

4.0095,
QUALITY FACTORS IN SORGHUM BREEDING LINES FOR LIVESTOCK, ENERGY AND INDUSTRIAL UTILIZATION
G.G. McBee, Texas A & M University, College Station Campus, Agricultural Experiment Station, Dept. of Soil & Crop Science, *College Station, Texas* 77843 (TEX06289)
OBJECTIVE: Determine genetic variability in major grain and forage sorghum breeding lines for cyanogenetic glucoside levels. Determine inherent variation in levels of certain carbohydrate fractions plus true and apparent digestibility of stover among selected grain and forage sorghum parental material. Evaluate stover for industrial and energy utilization.
APPROACH: Grow selected breeding lines under known population and fertility conditions. Flag leaf samples analyzed potentiometrically for p-HCN. Selected sections of plant analyzed for carbohydrates by hydrolysis and spectrophotometric technique and true and apparent digestibility by in vitro method. Energy and industrial determinations involve fermentation, mass spectrometry and calorimetric methods.
PROGRESS: Sorghum type plants rank as one of our most important forages, yet due to potential HCN (pHCN) poisoning of livestock, careful management must be exercised. Fifteen entries mostly from popular sorghum breeding lines were grown under nitrogen and maturity variables. Representatives were from Caffrourm, Feterita, Feterita-Candatum-Kaura, Caudatum-Kafir, Zerazera, Caudatum non-senescence, Milo, Zerazera non-senescence, Sudanease, Durra and Dochna. The youngest two leaves were analyzed for pHCN. Significant variation in pHCN among lines was obtained. Increases in pHCN was obtained with added N for lines inherently low in dhurrin. Significant decreases of pHCN were noted after plant inflorescenses were removed. Two publications on this are in progress. More efficient utilization of plant biomass for energy and other functions is becoming critical. Two contrasting types of sorghums, Rio and Combine Kafir 60, were grown under variable plant spacings and harvested at different dates on a selected diurnal cycle. Leaves were removed, culms sectioned, oven dried and processed for subsequent sugar analysis. More basic information of this type is needed for guidance on periods of harvest for maximum sugar concentrations.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Texas

4.0096,
ENGINEERING SYSTEMS AND ENERGY NEEDS FOR COTTON PRODUCTION
C.B. Parnell, Texas A & M University, College Station Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *College Station, Texas* 77843 (TEX03341)
OBJECTIVE: Improve energy management strategies for environmentally - and economically - acceptable cotton production systems. Apply engineering systems to the development of decision-making models for cotton production.
APPROACH: A systems engineering study of utilization alternatives of cotton gin trash to include use of gin trash as a source of biomass energy, compost, cattle feed and particle board will be pursued. This study will include a cotton gin simulation model designed to predict energy consumption as a function of ginning rate and trash content of cotton processed. Cotton dust studies will include evaluations of engineering dust controls for cottonseed oil mills.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Texas

4.0097,
SYSTEMS ANALYSIS OF COTTON GIN TRASH UTILIZATION ALTERNATIVES
C.B. Parnell, Texas A & M University, College Station Campus, School of Engineering, Dept. of Agricultural Engineering, *P.O. Box F E 44, College Station, Texas* 77843 (DAR77-21292 A01)
This action provides scheduled incremental funding for award DAR77-21292. The objective of this research is to develop a systems engineering model structured to permit the quantification of the energy, economic, and environmental costs associated with utilizing cotton gin trash. Alternatives to be studied include utilization as a cattle feed, as compost material, and as an energy source. The model will be used to determine the best alternative for gins processing picked and stripped cotton at rates of 10, 15, 20, and 50 bales per hour. Project results are expected to be useful in developing conceptual designs of systems for the safe utilization of cotton gin trash at minimum cost with acceptable rates of return on equipment and process investments.
During the initial period, cotton gin trash samples were collected, experiments on fluidized bed gasification and composting have been started and joint feasibility studies with Southwestern Public Service and Weyerhauser Company have been negotiated to examine gin trash as a supplementary fuel and as a composting material.
SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Applied Research

4.0098,
STUDY REFUSE SEPARATOR AND FLUIDIZED BED INCINERATOR FOR TREATMENT OF RURAL SOLID WASTES
H. Sheely, Texas A & M University, Prairie View A & M University, Agricultural Experiment Station, *Prairie View, Texas* 77445 (TEXX-PR-0001-G-6078)
OBJECTIVE: Determine the sources of solid and liquid waste contaminants in the Prairie View and closely related nearby areas. Determine the size of the incinerator needed based on community needs and future expectations. Evaluate and monitor the comparative performance efficiencies of the Multi-Use Incinerator model with special emphasis directed to additional desired modifications. Determine if waste materials from feed lots can be handled effectively by this experimental unit. Determine the possibility of using incinerator residue as a source of plant nutritional supplement. Investigate the utilization of waste heat to supply power more efficiently to rural farm families and/or other small communities and developments.
APPROACH: A Multi-Use Incinerator based on a two-foot diameter combustion can concept will be designed and fabricated. Effluents will be monitored and design alterations based on emissions detrimental to health will be made in order that these emissions can be reduced. Feed lot wastes will be used in the system in order to monitor the system's efficiency in disposing of animal wastes.
PROGRESS: A model of the Fluidized Bed Incinerator was designed with the help of Dr. H. B. Cooper of the University of Texas at Austin. The model is a circular cylinder one foot in diameter and five feet high. The upper 4 feet section is to be made of rolled alloy 330 stainless steel about 1/4 inch think to withstand the heat and pressure. Four 3' pipe openings with flanges are to being in refuse to be incinerated near the bottom while two openings near the top are to conduct away the exhause fumes. This upper chamber is to be partially filled with sand for the fluidized bed. The lower one foot section made of carbon steel consists of a funnel to bring in compressed air and a gas ring to bring in natural gas to ignite the refuse in the bed above. A # 60 wire mesh screen of 304 stainless steel supported by a coarse screen is blaced between the two sections to confine the sand in the upper section. The exhaust fume is to be cleaned by a venturi scrubber and cyclonic separator. Temperatures, pressures and air samples are monitored at various locations in the system. The majority of these equipments have been placed on order.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Texas

4.0099,
THERMOCHEMICAL PYROLYSIS OF BIOMASS TO MEDIUM-BTU GAS
S.R. Beck, Texas Tech University, School of Engineering, Dept. of Chemical Engin, *P.O. Box 4340, Lubbock, Texas* 79409 (EY-76-S-04-3779)
A pilot-scale partial oxidation reactor system has been constructed and operated for the production of synthesis gas from cattle feedlot manure. Current pilot scale data (25 to 50 lb raw manure/hr) confirm that an ammonia synthesis gas can be produced, as demonstrated in earlier investigations using a bench-scale reactor (0.3 to 1.0 lb manure/hr). The pilot-scale investigations indicate that ethylene and other C2 hydrocarbons potentially can be produced in the range of 50 to 180 lb per ton manure (daf), depending upon operating conditions. The partial oxidation reaction of manure has been studied at atmospheric pressure over an approximate average reactor temperature range of 600 degrees C to 800 degrees C. Cattle feedlot manure and air are the reactants in the partial oxidation, and steam is employed as a fluidizing medium. Other sources of biomass such as wood residue, corn stalks, etc., are now being tested as feedstocks in the pilot plant. Bench-scale tests indicate that product yields from these feedstocks should be similar to manure. This project is subcontracted.
SUPPORTED BY U.S. Dept. of Energy

4.0100,
FARMER OWNED AND OPERATED FUEL AND ALCOHOL STILL
L. Staengl, Floyd Agricultural Energy Cooperative, *Copper Hill, Virginia* 24079
SUPPORTED BY U.S. Dept. of Energy

4.0101,
GASOHOL DEMONSTRATION PROJECT, PENDLETON FARMERS SOCIETY, SOUTH CAROLINA
Unknown, Energy Policy Guidance Council, *Philippi, West Virginia* 26416 (CO-7157-79-I-302-0913)
The purpose of this project is to build and operate a small scale ethanol production unit using local agricultural products as raw materials. This is expected to demonstrate to farmers in Appalachia the viability of such an operation and thus promote the production of fuel from a domestic resource.
One of the alternative energy sources that has come to national attention in recent years is ethanol (ethyl alcohol) produced from agricultural crops. Ethanol can be mixed with fuel oil or gasoline to produce gasohol. The agricultural crops needed to produce ethanol are found widely throughout most of the Appalachian region - milo, wheat corn, barley, oats and sugar beets.
Unlike many other energy sources, ethanol has the attractive feature that it can be produced on a small scale. It is well suited to be produced by groups of farmers or farm cooperatives scattered in the region. A single farmer, however, may not be in the best situation to produce ethanol at a commercial scale in Appalchia because of the typically small farmsizes in the region.
Major elements of scope of work for this project are specified below: 1. To establish and implement formal procedures for the planning, management, production, marketing, and financing operations of the project; 2. To determine and bring to the local market the appropriate type and quantity of agricultural crops to produce ethanol; 3. To design and construct a 20,000 gallon per year ethanol production unit for portable use; 4. To provide the start-up for a self-sustaining ethanol/gasohol production and marketing operation; 5. To operate as near a self-sufficient energy system as possible. Maximum effort will be devoted toward the productive use of all inputs and outputs of the production system; 6. To maintain precise records of the costs of producing and distributing ethanol for farm use; and, 7. To report and communicate the findings of this project to the general public and special interest groups.
SUPPORTED BY U.S. Appalachian Regional Commission

4.0102,
THE ROLE OF MICROORGANISMS IN WASTE DISPOSAL
P.G. Moe, West Virginia University, School of Agriculture & Forestry, Dept. of Plant Sciences, *Morgantown, West Virginia* 26506 (WVA00244)
OBJECTIVE: Study: Anaerobic digestion for disposal of wastes generated in a family dwelling unit; disposal of effluent and sludge from community sewage disposal plants; generation of methane gas through the anaerobic digestion of animal manures; aerobic composting of manures; soil applications as a waste disposal system for industrial waste materials; disposal of acid mine drainage, and the disposal of industrial wastes in aquatic environments.
APPROACH: Laboratory and field experiments will be conducted of waste applications in aquatic and edaphic ecosystems. Systems will be evaluated for their microbiological populations and biological activity. Environmental factors will be manipulated to estimate optimum conditions for biological activity. Effects of toxicity, synergism and antagonism within the populations will be investigated.
PROGRESS: The microbial population of the bio-oxidation unit of recycling sanitary waste disposal system was shown to remain remarkably stable in spite of changes in operational and environmental parameters. Fecal coliforms were unable to establish

themselves in the indigenous microbial population, indicating that human pathogens would probably not survive in the system either. Gas chromatographic studies indicate that different constituents of a waste oil emulsion vary greatly in their susceptibility to microbial attack in the soil. Certain constituents even demonstrate a temporary increase in concentration, presumably as result of metabolic transformations. A most-probable-number-fermentation-tube technique has been developed and tested for enumerating populations of methanogenic bacteria in natural sewage sludge samples. The technique is simple to perform and highly reproducible. The addition of the enzyme catalase to selective culture media vastly improved the recovery of sublethally-injured Escherichia coli from environments containing acid mine water. Similarly, incorporation of catalase into standard plate count agar enhanced detection of 'total bactena' from acidic stream environments. Preliminary survival studies, using naturally occurring microbes associated with domestic sewage, has suggested a rapid die-away for sanitary indicator organisms when exposed to acid mine streams.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, West Virginia

4.0103,
NATURAL RED FOOD COLORANT FROM BEETS
S. Bernstein, Amber Lab., *330 S. Mill St., Juneau, Wisconsin* 53039 (AER76-24677 A01)
This award will provide incremental funding for NSF Grant AER 76-24677 which had previously been reviewed and approved as a two year continuing project. The objective is to assess the technical and economic feasibility of a process for the production of a red food color concentrate from red beet juice, together with feed grade beet pulp, food or feed grade yeast and ethyl alcohol as byproducts.
During the first year of the project, a yeast fermentation of red juice was optimized so as to provide rapid utilization of the fermentable sugars, good yield of yeast and alcohol and negligible loss of the red pigment. In the second year, the research tasks will be to: (1) Optimize the fermentation and recovery operations on a practical scale; (2) Establish the efficacy of the color concentrate on a vanety of food products; and (3) Assess the technical and economic feasibility of the process.
SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Energy & Resources Research & Technology

4.0104,
CONVERSION OF ANIMAL WASTES TO METHANE GAS AND TO SINGLE CELL PROTEIN USING PHOTOSYNTHETIC BACTERIA
J.C. Ensign, University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Bacteriology, *116 Agricultural Hall, Madison, Wisconsin* 53706 (WIS02342)
OBJECTIVE: The purpose of this investigation is to develop procedures for recycling of farm wastes. The products to be produced are methane gas, microbial protein and fertilizer. Another goal is concomitant formation of a low nutrient, non-polluting effluent solution. The ultimate goal is operation of rurally located factones for waste recycling.
APPROACH: Anaerobic fermentation of cow and chicken manures at meso- and thermophilic temperatures produce methane gas and high levels of volatile fatty acids. Comparisons of various fermentation operations will be made to optimize formation of gas and fatty acids. A separation step removes insoluble materials which can be used as fertilizer or feed supplement. The supernatant fluid is used to grow photosynthetic bactena which convert most of the organic matter into protein. A continuous flow system for efficient production of protein will be studied. The next phases of the investigation will involve scale up to pilot plant and, if economically feasible, to factory size operations.
PROGRESS: The purpose of this investigation is to efficiently convert animal wastes, particularly chicken manure, to energy as methane gas and to single cell protein. A 20,000 gal. fermentor located on a farm at Ripon, Wisconsin has been in operation for several years. The methane generation capacity has been improved until 4,000 cu. ft./day is now being produced. This amounts to a value of methane of only $4.05 per day. We are convinced that a major consideration for treating farm animal wastes by fermentation is to recover a protein-rich material to be recycled as animal feed. The particulate matter in the digestor effluent contains 20-25% by dry weight of protein. The liquid fraction is converted by use of photosynthetic bacteria into single cell protein. Over half of the initial weight of chicken manure can be converted to high quality single cell protein using the combined anaerobic digestion-photosynthetic bacteria treatments. Energy as methane gas is also produced and there are no potentially polluting effluent materials to deal with. Laboratory scale experiments indicate that the process is economically feasible.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Wisconsin

4.0105,
MICROBIAL ECOLOGY OF METHANE PRODUCTION IN AQUATIC ENVIRONMENTS
J.G. Zeikus, University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Bactenology, *116 Agricultural Hall, Madison, Wisconsin* 53706 (WIS02110)
OBJECTIVE: Characterization of the microbial anaerobic niche, as it occurs in aquatic sediments, in terms of: environmental parameters affecting bacterial methane formation; quantitative enumeration and kinds of methane bacteria present; determination of the in situ rates of methane production and decomposition of organic matter; determination of the preferred substrates employed by methane-producing bacteria present. Isolation of bacterial species responsible for methane formation in aquatic sediments and specification of their important properties, in terms of: determination of general properties, nutritional requirements and growth rates; determination of the rates of methane production and factors which influence this process; establishment of taxonomic identity and characterization of new species.
APPROACH: Characterization of bacterial methane formation as it occurs in nature by employing in situ experimentations. Quantitative enumeration of methane-producing bacteria present in sample sediments. Isolation of pertinent bacterial species and characterization of their morphological, nutritional and physiological properties.
PROGRESS: Microorganisms involved in the mineralization of organic matter in Lake Mendota sediments were isolated and characterized. New strains of Desulfovibrio vulgaris were demonstrated to grow on H(2) as the sole energy source for growth. This species was shown to be important in mineralization of organic matter before sulfate becomes limited in Lake Mendota sediment. A new strain of Methanosarcina barkeri was shown to metabolize CH(3)OH, CH(3)NH(2), H(2)/CO(2) or acetate to methane. The species was the predominant acetate fermentor in Lake Mendota and was important in carbon mineralization because the rate of unitrophic or mixotrophic utilization of acetate in lab cultures was far greater than the rate observed in nature. Methanosarcina barken was also shown to metabolize methylamine, an important fermentation product of decaying animal matter. Physiological studies characterized the pathway of methanol, H(2)/CO(2) and acetate metabolism. Conversion of all immediate precursors to methane involved common carbon carriers. Acetate metabolism was demonstrated to be the rate limiting step in conversion of immediate methane precursors by M. barken. In sediments, however; the rate limiting step in carbon mineralization was conversion of particulate matter. (Text Truncated Exceeds Capacity)
SUPPORTED BY Wisconsin State Government

4.0106,
ALCOHOL AS A FUEL FOR DIESEL FARM AND CONSTRUCTION EQUIPMENT
Unknown, University of Wisconsin, Madison Campus, School of Engineering, Dept. of Mechanical Engineering, *Madison, Wisconsin* 53706
SUPPORTED BY U.S. Dept. of Energy

4.0107,
DEMONSTRATION OF FARM BIOGAS DIGESTER AND ALGAE BASINS
Unknown, Mariana Islands Div. of Agriculture, *Saipan, Mariana Islands* 96158
SUPPORTED BY U.S. Dept. of Energy

4.0108,
OPTIMIZATION OF ANIMAL WASTES TREATMENT WITH REFERENCE TO BIOTREATMENT, RECOVERY OF GAS, PROTEINS AND AGRICULTURAL UTILIZATION OF EFFLUENTS
J.A. Oleszkiewicz, Research Inst. on Environmental Development, Wroclaw Division, *Wroclaw, Poland* (L770D-F002)
OBJECTIVE: The project will attempt to optimize the existing treatment system for a large hog farm and evaluate the production of bio-gas, production of protein and the production of yeast from the wastes. Also land application of the effluent will be evaluated for possible ground and surface water contamination. The project will produce a report detailing the processes investigated, their efficiencies and the economics of each system. The initial laboratory scale work is complete. Field work completed and final report is being prepared.
PROGRESS: The outline of the final report was approved in September 1979 and a draft of the report will be in U.S. in April 1980. A paper based on the project will be presented at ISLW-80 in April 1980.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Robert S. Kerr Environmental Research Lab.

5. ENERGY FROM FOREST PRODUCTS AND RESIDUES

5.0001,
IMPROVEMENT OF WOODBURNING HEATERS AND FIREPLACES
D.F. Dyer, Auburn University, School of Engineering, Dept. of Mech Engin, *Auburn, Alabama* 36830 (EC-77-S-05-5552)
The contractor will conduct a research program to improve the energy efficiency, safety, and utility of wood burning heaters and fireplaces. Analytical and experimental studies will be performed to achieve this objective and provide a data base for use in hardware design, installation, and consumer instruction.
SUPPORTED BY U.S. Dept. of Energy, Office of Fossil Energy

5.0002,
SOIL TREATMENT OF RESIDENTIAL SOLID FUEL COMBUSTION FLUE GASES
H. Bonn, University of Arizona, School of Engineering, Dept. of Soils/Water & Engineering, *Tucson, Arizona* 85721 (F830M-792220)
OBJECTIVE: Assess soil treatment as a means of controlling air pollution from residential wood and coal combustion. The control technology concept which has already been developed will be evaluated in a demonstration unit that is to be constructed.
APPROACH: Develop design parameters and operational limits for soil filtration systems for removing air pollution from residential solid fuel combustion processes.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

5.0003,
THE USE OF UNDERSTORY VEGETATION - A RENEWABLE BIOMASS ENERGY RESOURCE
T.T. Ku, University of Arkansas, Monticello Campus, Undergraduate School, Dept. of Forestry, *Monticello, Arkansas* 71655 (ARK)
OBJECTIVE: Determine nature, character and extent of understory vegetation within uneven-aged pine and pine-hardwood southern forests as a renewable biomass energy resource. Determine attitude of non-industrial landowners toward public harvest of understory. Determine recovery rate of resource after harvest. Determine long term effects of periodic harvests of understory biomass and site quality.
APPROACH: A factorial experiment with two forest types, two site classes, two density classes, and five replications will be used to establish 40 main plots in the South Arkansas and North Louisiana area. Main plots will be approximately 0.5 acres in size. Three 10'x 10' paired sub-plots will be established with all understory vegetation below 5.6' dbh to be harvested by clipping from one plot of each pair in summer and the second plot to be harvested in winter. Subsamples from the green chips will be ovendried and used to determine baseline data for quantifying long term effects of periodic harvest on site quality. Landowners will be canvassed to assess availability of understory biomass for energy
SUPPORTED BY Arkansas State Government

5.0004,
WOODBURNING POWER PLANT
Unknown, Cohen M Collective, *Santa Cruz, California* 95060 (EM-78-G-03-1937)
SUPPORTED BY U.S. Dept. of Energy

5.0005,
OXIDATIVE UTILIZATION OF WOOD AND OTHER LIGNOCELLULOSIC MATERIALS
D.L. Brink, University of California, Berkeley Campus, Agricultural Experiment Station, McIntire Stennis Program, *Berkeley, California* 94720 (CA-F#-FPL-2910-MS)
OBJECTIVE: Based upon oxidative reactions develop technically and economically feasible/and environmentally compatible processes utilizing wood and other lignocellulosic materials.
APPROACH: Using oxidizing agents modify the lignocellulosic moiety in wood and residuals of forestry and agriculture to produce products of commercial value.
PROGRESS: Oxidative hydrolysis-wet combustion-fermentation was designed as an environmentally benign process to produce ethyl alcohol (for fuel), methane, process energy requirements, and optionally, acetic and other organic acids. A proposal was submitted to USDA for a pilot project on this process under Public Law 95-113, Section 1420. Delignification: Oxidative pretreatment of pulp chips using oxides of nitrogen includes two systems: gaseous nitric oxide oxygen (NO) and aqueous nitric acid (NAL). Followed by soda pulping as a second stage (NALS) pulps produced had properties approaching those of NOS kraft pulps. Characterization of NOS black liquor has included organic acids and precipitable lignin. Lignocellulose modification: A. Bonding (interproject with 2904 and 2926) by NAL pretreatment of wood flakes followed by application of a crosslinking agent, gave particleboards with superior overall properties in the 0.45-0.75 density range compared to those obtained using hydrogen peroxide in the pretreatment stage. B. Of pretreatments studies, NO was most efficient for improving enzymatic hydrolysis of cellulose to glucose (cooperative study with Mr. Ron Borrevik and Prof. C. W. Wilke, Chem. Eng. Dept. Structural analysis of lignin: two papers were presented at the May, 1978, meeting of TAPPI-ACS, Appleton, Wisc.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

5.0006,
PYROLYSIS-GASIFICATION OF ORGANIC RESIDUES--FOREST & AGRICULTURE--FOR ENERGY AND PRODUCT RECOVERY
D.L. Brink, University of California, Berkeley Campus, Agricultural Experiment Station, Dept. of Forestry & Conservation, *Berkeley, California* 94720 (CA-F#-FPL-2905-H)
OBJECTIVE: Develop data for design of processes involving production of energy, isolation of fuel gases and/or organic chemicals, and/or inorganic chemicals of value from biomass residual generated in forestry and agricultural enterprises.
APPROACH: Bench-scale reactor will be redesigned and operated specifically to provide indirect heat by incorporating down- or cross-draft gasifier with shaft or rotary-type gasifier to maximize production of energy, organic products of value, and/or syn gas.
PROGRESS: Continued study of the Pyrolysis-Gasification-Combustion (PGC) process for converting biomass materials or their derivatives to chemicals and/or energy includes: A. Completing and submitting the final report to EPA demonstrating technical feasibility of the PGC process applied to kraft black liquor (KBL). The PGC experimental unit and its operation at 2.0 metric tons (MT)/day of 45% solids KBL were described in detail. Especially significant results are: continuous conversion of KBL solids to only smelt and PG gas, smelt comprises Na(2)CO(3) and Na(2)S--reduction to sulfide is over 90%, PG gas contains only H(2), CO, CO(2), H(2)O, CH(4), N(2), Ar, and H(2)S--no malodorous, sulfur-containing organic compounds are present. Methods used to predict scale-up of operations to a 91 MT/day commercial module and a 1365 MT/day recovery plant have been published. It is predicted on a commercial scale: less than 10% of the total sulfur of KBL will be converted to H(2)S, on scrubbing H(2)S can be virtually eliminated, H(2)S not removed will be converted to SO(2) on combustion of PG gas and SO(2) can be controlled within a prescribed limit, scrubbing will remove dusty by nucleation as the PG gas is colled below its dew point, thus eliminating electrostatic precipitators, smelt-type furnace explosions will be prevented by elimination of steam generation and water cooling of walls and floor. B. KBL used to scrub H(2)S from PG gas.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

5.0007,
CHEMICAL REACTIONS OF WOODS AND BARKS
D.L. Brink, University of California, Davis Campus, Graduate School, *Davis, California* 95616 (CA-F#-FPL-1834)
OBJECTIVE: Materially reduce and, if possible, eliminate air and water pollutants produced in the chemical processing of ligno-cellulosic material. Develop new processes and modify existing processes for treating ligno-cellulosic material to produce such end products as paper and board making fibers, chemicals and energy.
APPROACH: Pyrolysis and oxidation reactions will be evaluated for effectiveness in reducing or eliminating pollutants. Nitric acid and other reagents will be studied to determine effectiveness in processing wood and bark.
PROGRESS: A total of 37 articles (A), 18 theses (12 MS, 6 PhD), patents (P) and 36 UCFPL Technical and 24 UCFPL !nternal Reports were published. Publications included: Pulping Studies: pulp properties (4A) kraft and polysulfide pulping (2 MS, 1 P); conventional bleaching NOS pulp (1 MS). Oxidative Studies: wet oxidation with oxygen (5A, 1 MS, PhD, 1P); pretreatments with oxides of nitrogen including HNO(3) in: a. pulping via nitric oxide-oxygen-soda (NOA) and nitric acid-soda (NALS) (5A, 1 MS, 1 PhD), b. bleaching (1 MS) and c. particleboard bonding (1 MS); alkaline nitrobenzene oxidation (3A, 2 MS, 1 PhD) and a comparison of oxidations (1A). Hydrolytic Studies: (2A, 1 MS); Pyrolysis-Gasification-Combustion Studies: a. pulping liquors (11A, 1 MS, 3 PhD), b. wood (1A, 1 MS), c. municipal solid wastes (3A), a combination of materials (1A, 1P). Two projects (2905 and 2910) were initiated based on work carried out herein and should be referred to for continuing work in the specified areas. Four processes were developed on the basis of work initiated under this project, i.e., hydrolysis-wet oxidation-fermentation, NOS and NALS (nonsulfur) pulping, oxidative pretreatment-crosslinking agent formation of particleboard (all continued under AES Project No. 2910) and pyrolysis gasification-combustion (continued under Project No. 2905).
SUPPORTED BY California State Government

5.0008,
AIR POLLUTION EMISSION INVENTORY OF FIREPLACES
R. Buchan, Colorado State University, College of Veterinary Medicine & Biomedical Sciences, Dept. of Microbiology, *Fort Collins, Colorado* 80523 (COLV05514)
OBJECTIVE: Provide accurate information on the impact of fireplaces as an air pollution source in Vail, Colorado so that sound decisions can be made with respect to emission control strategies.
APPROACH: This initial phase of the project will be for the purpose of gaining background information, refining experimental design, developing a data tublation format and data analysis model. Second phase of the project will be devoted to data collection. The time period of this phase was selected as it is the peak ski season and fireplaace usage should be at its highest. Final phase of the project will be for data analysis, evaluation, conclusions and preparation of report with recommendations. Data collected will be analyzed in accordance with established statistical methods and evaluated accordingly.
SUPPORTED BY U.S. Dept. of Agriculture

5.0009,
MARKETS AND MARKETING OPPORTUNITIES AS APPLIED TO COLORADO FOREST PRODUCTS
D.R. Betters, Colorado State University, School of Forestry & Natural Resources, Dept. of Forest & Wood Sciences, *Fort Collins, Colorado* 80523 (COL00071)
OBJECTIVE: Identify alternative utilization and marketing strategies that are technically and economically feasible for near-total consumption of wood raw materials generated by mountain pine beetle control programs, evaluate the relative economic merit of alternatives, and recommend procedures needed to implement the most favorable strategies. Determine the market areas, volume, and value for existing products, and other possible new products now currently being produced in Colorado and evaluate production and marketing alternatives that can be supported by various levels of forest management.
APPROACH: The methodology will consist of several segments or phases, identify potential market areas, identify characteristics of the market areas relating to consumption of forest products, develop and test alternative production and marketing strategies based on raw material available, product potentials and market demand and relate the suggested strategies to forest management programs for Colorado.
PROGRESS: Emphasis for research needs will be in the area of domestic fuelwood energy alternatives in the State of Colorado. These include firewood, pelletized fuelwood, biomass conversion, and mill and logging residues as domestic fuelwood. A further breakdown of research needs in these areas include markets, supply, economic efficiency, energy efficiency, and environmental and other non-market considerations. Since the research needs in the wood energy field are quite extensive, a methodology is now being developed to prioritize these needs so that an effective study plan can be designed. The general format of the study plan involves the identification of fuelwood energy alternatives, examples of existing alternatives, circumstances making these alternatives viable and areas in Colorado where similar circumstances exist.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Colorado

5.0010,
MAN AND THE BIOSPHERE WORKSHOP ON ENERGY AND ORGANICS FROM FOREST BIOMASS
O. Olson, U.S. Dept. of State, Committee on Man & Biosphere, *Washington, District of Columbia* 20520
SUPPORTED BY U.S. Dept. of Energy

5.0011,
DEVELOPMENT OF A RESIDUE BURNER, COMBUSTION OF WOOD, ADHESIVES, AND A MOBILE CHIPPER FOR RECOVERING FOREST RESIDUES FOR ENERGY
P. Koch, U.S. Dept. of Agriculture, Forest Service, *Olustee, Florida* 32072 (SO-3201)
Determinations were made of: phenolic metabolites of Ceratocystis minor, fatty and wax components in southern pine bark, structure and reactivity of polyflavanoids in southern pine bark, and hygroscopic properties of 22 southern hardwoods. Conversion processes were developed as follows: cellulose ethers made directly from defibrated hardwoods; 7-by 9-inch crossties made from logs only 8-1/2 inches in diameter; manufacture of mixed-species structural flakeboard (80% southern hardwoods) elucidated; manufacture of structural panels with flake cores and veneer faces demonstrated; adhesives for these panel types developed; two machines advanced from prototype stage to commercial use--the shaping-lathe headrig and a machine to pull trees with central root mass intact; an energy self-sufficient system (Biomass Retrieval and Utilization with Shaping-Lathe Headrigs) conceived for conversion of 67% of forest biomass, all species and all tree diameters, into products worth $150/OD ton; a machine to harvest standing culls and logging residues conceived; a cooperative agreement to construct a commercial prototype of a green bark burner invented by the RWU executed; a new concept in high-yield mechanical pulping demonstrated; the technology of manufacture of fiberboards from southern hardwoods advanced; a tunnel kiln to dry 1.75-inch-thick southern pine lumber to 9 percent moisture content in 12 hours invented; and a study of material balances and energy required for manufacture of 10 wood commodities published.
BIBLIOGRAPHIC REFERENCES: Koch, P., 1976, Part I--Key to Utilization of Hardwoods on Pine Sites: The Shaping-Lathe Headrig, Forest Ind., 103(11): 49-51; Part II--New Approaches, New Machines to Utilize Hardwoods on Pine Sites, Forest Ind., 103(12): 22-25; Part III--All Processes to Utilize Hardwoods on Pine Sites Can Be Combined, Forest Ind., 103(13): 24-27
SUPPORTED BY U.S. Dept. of Energy

5.0012,

QUANTIFICATION OF WOOD ENERGY RELATIONSHIPS

J.W. McMinn, U.S. Dept. of Agriculture, Forest Service, Southeastern Forest Experiment Station, *Athens, Georgia* 30601 (SE-4151)

OBJECTIVE: Develop: Techniques for systematic geographic analyses of development opprotunities; predicitions of yields and environmental impacts from energy-related management systems; cost and energy budget estimates.

APPROACH: Eastablish statistical relationships of energy wood as function of available data and apply by state and physiographic province. Conduct designed studies of yields and environmental impacts. Construct simulation models with existing data for costs and energy budgets.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Southeastern Forest Experiment Station

5.0013,

UTILIZATION OF SOUTHERN TIMBER

M.A. Taras, U.S. Dept. of Agriculture, Forest Service, Southeastern Forest Experiment Station, *Athens, Georgia* 30601 (SE-3101)

OBJECTIVE: Charactenze the southern timber resource and develop the technology to improve utilization processes, product yields, reduce waste, and conserve energy.

APPROACH: Research studies will be conducted to determine the total-tree biomass of southern softwood and hardwood species, so we can determine how much additional fiber is obtained when tops, branches, root systems, understory trees, and cull trees are harvested. Physical and chemical properties of wood and bark will be examined to determine their influence on product utilization. Trees and logs will be followed through primary processing, when possible, to determine ways of improving lumber, veneer, pulp, and fuelwood yields.

PROGRESS: Increaseing demand for wood for a vanety of products has led to some new approaches to wood utilization. Whole tree utilization has been investigated for the four major southern pines and for some of the commercially important hardwoods in the Southeast. Results show that fiber or energy wood yields could be increased by 16 to 24% for pine and by 10 to 55% for hardwoods if the unused bole and crown of pulpwood and sawtimber trees were utilized. An additional 18% could be realized if pine roots were harvested. As the average log size continues to shrink in the South, composite studs and panels take on more importance. A study of tree veneer yields showed that about 30% of the volume from a typical southern pine stand can be processed into grade C and better face veneers for composite products-more than enough to supply the face veneers for COM-PLY studs. Also, about 92% of the volume in a typical southern pine stand can be used in COM-PLY panels. This is more than twice the volume that would go into conventional plywood from the same trees. Investigation of the use of hardwood total-tree chips in the manufactures of medium and low density fiberboards showed that these boards can be produced without signigicant processing difficulties. The low density board has excellent potential as a substrate for grain printing, wood veneering, and vinyl overlays, and as core material for lighweight composite panels.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Southeastern Forest Experiment Station

5.0014,

VOLUME TABLE AND PRODUCTION TIME FOR HARDWOOD FIREWOOD

C.W. Mize, Iowa State University of Science & Technology, Iowa Agricultural & Home Economics Experiment Station, Dept. of Forestry, *Beardshear Hall, Ames, Iowa* 50010 (IOW02293)

OBJECTIVE: Develop a composite firewood volume table for oak and hickory and determine the time and cost required to perform various phases of firewood production.

APPROACH: Cut a sample of trees of various sizes into firewood and measure the volume produced. Adapt an old table from Pennsylvania or develop a new one. Do a time motion study of firewood production and determine various costs.

SUPPORTED BY Iowa State Government

5.0015,

EVALUATION OF WOODLAND MANAGEMENT OPPORTUNITIES IN IOWA

P.H. Wray, Iowa State University of Science & Technology, Iowa Agricultural & Home Economics Experiment Station, McIntire Stennis Program, *Beardshear Hall, Ames, Iowa* 50010 (IOW02172)

OBJECTIVE: Determine the effects of past and present management practices on private woodlots and the existing forest cover. Develop better guidelines and management tools for management of Iowa forest resources for fiber production. Evaluation of alternative uses for forested land such as pasture, recreational developments, cropland and urban development. Reevaluate the effect of tree barriers on wind movement.

APPROACH: Develop better yield and growth information for selected hardwoods. Study response of selected species to cultural treatments. Study and monitor regeneration techniques, as to type of natural regeneration that occurs with respect to species, density and time. Study in select counties the history of past forest and non-forest use and analyze the influence of past practices on present conditions.

PROGRESS: The small woodlot simulation model was completed. IOWOOD is a sumulation model which models the small woodlot typical to Iowa. Fuelwood volume tables for both red oak and white oak have been developed. Both total tree and logging slash tables have been developed. These are significantly different from existing tables. Work is in progress to look at the economics of fuelwood projection in Iowa. A study is nearing completion of ten Iowa counties segregated by their 1954 percentage of land area in forests to determine the magnitude of forest loss due to land use changes.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Iowa

5.0016,

VARIATION IN PROPERTIES OF WOOD AND BARK OF SECOND-GROWTH SWEETGUM TREES

E.T. Choong, Louisiana State University, Agricultural & Mechanical College, School of Forestry & Wildlife Management, Mcintire Stennis Program, *University Station, Baton Rouge, Louisiana* 70803 (LAB01682)

OBJECTIVE: Compare selected anatomical, physical, and chemical properties of sweetgum wood and bark. Determine the variation of these properties within and among trees growing in a bottomland and an upland site. Characterize some of the extractives and minerals in wood and bark.

APPROACH: Obtain wood and bark samples from various heights in trees growing on bottomland site and upland site. Properties to be determined are: green moisture content, equilibrium moisture content, specific gravity, differential shrinkage, toughness, tissue content, dimensions and fibril angle of fiber tracheid, tension wood, interlocked grain, extractives content, mineral contents, pH, and heat of combustion. In addition, attempts will be made to isolate pure fractions of the phenolic compounds and identify them by comparison with known compounds chromatographically and spectrographically.

PROGRESS: The wood and bark of sweetgum were extracted with ethanol and fractionated for chromatographic examination. Individual components were then isolated and characterized by their R values, color reactions and spectral properties. Ellagic acid and gallic acid were both found in bark, and in sapwood and heartwood. Dihydroquercetin (taxifolin) was found in the sapwood, and there is strong evidence for quercetin in the heartwood; but these compounds were not major constituents of the bark. A mixture of methylated ellagic acids is suspected in the bark but could not be detected in either sapwood or heartwood. Preliminary work was done to determine the axial and lateral variations of specific gravity and fiber length on two sweetgum trees. Data are currently being analysed. Samples for studying wood characteristics are being collected from 3 trees each of six locations to encompass wide geographical areas in Louisiana, representing various bottomland (wet) and upland (dry) sites. The variations in specific gravity, fiber length, tissue types, cell dimension, green moisture content, and hygroscopicity within and between trees are being studied. Fuel values (in terms of BTU per M Bd. Ft. Doyle of wet material) and volumes for sweetgum bark compared favorably with several Delta hardwood barks obtained in two mills in Louisiana. The ultimate fuel values are dependent largely on log and bark storage conditions and processing methods.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Louisiana

5.0017,

ASSESS FEASIBILITY OF CONVERTING WOOD RESIDUES TO LIQUID AND GASEOUS FUELS VIA GASIFICATION

A.C. Nyce, Gorham International Inc., *Gorham, Maine* 04038 (ET-78-C-02-4862)

SUPPORTED BY U.S. Dept. of Energy

5.0018,

STUDY OF SMALL SCALE WOOD COMBUSTION FOR SPACE HEATING

R.C. Hill, University of Maine, Orono Campus, Graduate School, Dept. of Industrial Cooperation, *36 Winslow Hall, Orono, Maine* 04473 (EC-77-S-02-4559)

Task 1: The contractor will construct a 100,000 Btu/hr, stick-wood fired furnace complete with water heat exchanger and storage tank. The unit will be similar in concept to the unit shown in Figure 3 of the proposal. The shape of the combustion space and the manner of introducing primary and secondary air will be flexible so that a broad performance data base can be generated. The goals of cost, efficiency, convenience and low emission will be articulated. Tests will be conducted to determine the effect of wood quality--species, moisture, area-volume ratio, etc. The aim is to not only analyze the variables leading to design; but to develop a test chamber for possible subsequent work on small scale home or industrial combustion systems. Task 2: The data base will be extended as needed to provide a design and operation manual which will be prepared in photo-ready form for the government.

SUPPORTED BY U.S. Dept. of Energy

5.0019,

MARKETING AND UTILIZATION OF MAINE FOREST PRODUCTS AND ECONOMICS OF INTENSIVE MANAGEMENT OF MAINE FORESTS

D.B. Field, University of Maine, Orono Campus, School of Forest Resources, *302 Boardman Hall, Orono, Maine* 04473 (ME42802)

OBJECTIVE: Provide information which will enhance the ability of Cooperative Forestry Research Unit sponsors to grow timber extract (and possibly process) that timber, and merchandise the resulting products in such a way as to maximize the long-run return (monetary or otherwise) on the fixed elements of the investments involved, subject to socio-economic and bio-physical realities.

APPROACH: Compile resume of relevant research completed or ongoing within the School, the sponsor group, other academic institutions, the state, and the Federal government. Meet with and tour the lands of the major sponsors. Develop a 5-year program analysis for sponsor review, followed by detailed project proposals. Begin specific project program research.

PROGRESS: Three formal sub-projects are in process: (1) a problem analysis of utilization limitations caused by degradation of spruce-fir timber following attack by eastern spruce budworm (Choristoneura fumiferana) (Clem.), (2) a study of the potentials for a Maine hardwood charcoal industry, and (3) a comprehensive study of public benefits from private forest land ownership and management in Maine. The spruce-fir degradation study has produced a comprehensive review of work done on the degrade and decay of Northeastern conifers, primanly balsam fir (Abies balsamea (L.) Mill.). Supplies of undamaged timber are still large enough so that little insight has been gained in Maine into problems associated with sawing or pulping damaged wood. The charcoal study has produced an analysis of the potentials for improving Maine's hardwood forests by using low-grade timber to produce charcoal for domestic space heating. Charcoal delivered at $120/ton is the equivalent (in $/BTU) of wood (burned in stoves) at $106/cord, wood (burned in furnaces) at $138/cord, fuel oil at $0.74/gallon, and electricity at $0.0286/kilowatthour. If 16% of Maine's residential space heating needs could be met with charcoal fuel, half of the state's 140 million cubic meters of low-grade timber could be used over an interval of 20 years.

SUPPORTED BY Maine State Government

5.0020,

ENGINEERING CONCEPTS FOR INTENSIFIED HARVESTING OF FORESTS

H.M. Soule, University of Maine, Orono Campus, School of Forest Resources, McIntire Stennis Program, *302 Boardman Hall, Orono, Maine* 04473 (ME09003)

OBJECTIVE: Develop conceptual designs for equipment to carry out forest intensification pilot program.

Mathematically simulate a growing forest to predict effects on fiber yield of intensification methods such as partial harvesting, superior variety selection, fertilization, and improved forest management techniques.
APPROACH: Conceptualize equipment designs for lane management. Conceptualize equipment for precommercial thinning from lanes. Simulate effects of intensification on forest stands. Construct equipment as needed and test the lane management concept.
PROGRESS: A study of productivity and operating and capital costing of logging equipment has been completed and published. This investigation has formed the basis for establishing legal monetary allowances guidelines by the U.S. Dept. of Labor and its state affiliate for equipment useage in Maine. Additionally a computerized procedure for evaluating equipment replacement has been formally introduced into a program repository maintained by the Amer. Soc. of Agric. Engineers. A proposed rotary chipping head for use with a small, boom-mounted thinning device has been laboratory tested and found to be feasible for use with woody stems up to 5 cm. diameter. Work is now underway to modify this concept to a thinning unit. Work on a felling and chipping mechanism to harvest brush along state highway began in November. The project involves designing and constructing a boom-mounted head to fell and chip roadside brush and then convey the chips to some accesable location for transport. These brush chips will be used as fuel for heating.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Maine

5.0021,
PORTABLE UNIT FOR PYROLYSIS OF AGRICULTURAL WASTES

H. Kosstrin, Energy Resources Co. Inc., *185 Alewife Brook Pkwy., Cambridge, Massachusetts* 02138 (B624B-511)
OBJECTIVE: The objective of this program is to determine the environmental, technical, and economic feasibility of a mobile pyrolysis unit to convert agricultural and forestry residues to an energy form. The development of such a technology that takes an environmental liability and converts it to an environmental and energy asset is highly desirable. To this end the contractor will design, fabricate, and field test a moble pyrolysis system caple capable of meeting or exceeding the concept criteria established by previous work.
APPROACH: This work shall consist of the design, fabrication, and field testing of a prototype mobile pyrolysis unit capable of processing agricultural and forestry residues into usable fuel products. The existing concept envisions a unit capable of processing 100 dry tons per day of agricultural waste. The system concept includes a dryer, shredder, reactor, gas cleaning, oil recovery, char recovery, and support equipment, all mounted on two or three trailers meeting highway road height, width, and weight limits.
PROGRESS: The contractor has completed the conceptual design, 75 percent of mechanical design, and will start fabrication by June, 1979.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

5.0022,
WOOD RESIDUES AS FUEL STOCK FOR WOOD GAS GENERATORS

W.W. Rice, University of Massachusetts, Amherst Campus, Agricultural Experiment Station, McIntire Stennis Program, *Amherst, Massachusetts* 01002 (MAS00026)
OBJECTIVE: Characterize residues available for fuel in terms of quantity, source, variability, form, bulk density, moisture and BTU content. Develop cost-performance data. Develop material specifications.
APPROACH: Research is divided into discrete units based on source and differences in factors affecting efficiency of use of residues -forest residues, mill residues, urban waste.
PROGRESS: This project was established by installing a 500,000 BTU steam boiler, wood gasification generator and sufficient radiation for tests in the Wood Processing Center. The work was done by the Principal Investigator with the assistance of students and the advice of University technical and maintenance personnel. A system for storing, transporting, drying and feeding chips as fuel was designed and partially completed. An agreement was made with a local sawmill owner for a continuing supply of chips from sawmill residue. Future work will include completion of a reliable feed system and development of the furnace as a demonstration unit.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Massachusetts

5.0023,
USE OF REMOTE SENSING FOR LAND USE POLICY FORMULATION

R.D. Viasin, Michigan State University, Agricultural Experiment Station, Dept. of Resource Development, *New Administration Bldg., East Lansing, Michigan* 48823 (MICL01168)
OBJECTIVE: To demonstrate the operational ability and uses of remote sensing for land use planning and policy formulation. Specifically to: develop, apply, and evaluate a system which will incorporate remote sensing for classifying land use and resource characteristics; apply remote sensing to program needs of selected Michigan agencies; apply the findings of the research to the land use policy formulation process in Michigan.
APPROACH: Actual sites selected with governmental units to test usefulness of various RS applications. 'Short-term' direct agency applications to permit development, completion, evaluation, and approaches. Applications also to longer-run policy efforts. Departments of Crop & Soil Sciences, Forestry, Resource Development, Urban Planning & Landscape Architecture, and Geography are involved.
PROGRESS: During 1978, remote sensing techniques were used to derive data required for effective land/resource use decisions by agencies in Michigan. Photo-derived information on open water and marshes, forested wetlands, and residential areas in Saginaw and Bay counties is being used by field teams in mosquito treatment operations. A vegetation inventory of the Shiawassee National Wildlife Refuge was prepared. A procedure was developed to identify 'wild areas' using LANDSAT and aerial imagery. The Michigan Department of Natural Resources will use information provided for six counties to select sites for dedication as natural preserves. LANDSAT imagery, supplemented by NASA PB-57 and other aerial photography, is being used to determine the location, extent, and biomass of noncommercial timber resources in west central Michigan. The information will be used by private firms in planning for two wood-chip burning electric power generating plants. Temporal aerial photos are being used to assess the environmental (particularly drainage alteration) impacts of existing gas and oil pipelines crossings of streams and wetlands. The study is aimed at identifying better pipeline construction methods which prevent or mitigate impacts on sensitive environments. Project personnel have developed a sand dune morphology classification for the shore zone of Michigan and procedures for inventory and monitoring of sand dune mining operations using aerial imagery.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Michigan

5.0024,
TIMBER MARKETS DYNAMICS

R.S. Manthy, Michigan State University, School of Agriculture & Natural Resources, McIntire Stennis Program, *Soil Science Bldg., East Lansing, Michigan* 48823 (MICL01149)
OBJECTIVE: Incorporate into timber market projection models procedures for analytical recognition variables which reflect dynamic aspects of modern society. Determination of the sensitivity of future timber demand to changes in government, environmental economic policies and other dynamic variables.
APPROACH: Multi-equation models of the timber markets of concern will be developed and tested for statistical integrity, sensitivity and importance as timber supply and demand shifters.
PROGRESS: A study plan for 'A Study of the Economics of Sludge Dispersal on Forested Lands' has been prepared. Sludge dispersal methods have been observed and documented. Alternative econometric models for a study of 'Technological Advances in the Panel Products Industry' have been explored and evaluated for suitability for further expansion. A draft manuscript dealing with the role of technological change on price and availability of the lumber. Plywood has been prepared. Impacts of future technological developments upon wood supply requirements for these industrial are considered. A draft 'Assessment' has been prepared which documents the status and likely future condition of the renewable forest resource of the State of Michigan. A tentative study plan has been prepared for a study of 'The Impact of Wood Fuel Markets and Traditional Timber Products Markets in the Midwest.' A major study of 'Trends on National Resources Commodities' was completed. The study demonstrated that during the period 1870-1973 there is no clear statistical evidence of increasing resources scarcity.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Michigan

5.0025,
ENERGY AND PROTEIN PRODUCTION FROM PULP MILL WASTES

Unknown, Michigan Technological University, Graduate School, *Houghton, Michigan* 49931 (EY-76-S-02-2983)
SUPPORTED BY U.S. Dept. of Energy

5.0026,
NUTRIENT UTILIZATION IN INTENSIVELY CULTURED FOREST CROPS

J.R. Boyle, University of Michigan, Ann Arbor Campus, School of Natural Resources, *Ann Arbor, Michigan* 48104 (MICY00070-F)
OBJECTIVE: Evaluate nutrient requirements of intensively cultured forest crops. Evaluate capacities of soils to supply these nutrients.
APPROACH: Review the literature and file data on nutrient uptake of intensively cultured forest crops and related information on soil supplies of nutrients and ecosystem nutrient dynamics. Analyze data on soil properties and plant nutrient contents for whole-tree chipping operations. Calculate preliminary nutrient budgets and define additional needed research.
PROGRESS: The review of literature continued. Work continued on refining calculations of impacts of nutrient removals due to whole-tree chipping, especially in relation to wood for electricity generating. In cooperative effort with the North Central Forest Experiment Station, work was initiated to evaluate impacts of sewage effluent irrigation on mycorrhizal development in maple and beech. This effort will provide baseline information for considering sewage effluent as a component of intensive culture systems. In cooperation with an internally funded project, an evaluation of impacts of inputs of nutrients and acids from natural precipitation was started. This work will add to knowledge basic for understanding nutrient inputs, transformations, and outputs in intensively cultured forest tree systems.
SUPPORTED BY Michigan State Government

5.0027,
DEVELOPMENT OF WOOD-ENERGY PROJECT

G.R. Gregory, University of Michigan, Ann Arbor Campus, School of Natural Resources, Dept. of Fisheries Forestry & Wildlife, *Ann Arbor, Michigan* 48104 (MICY00116-F)
OBJECTIVE: Develop a multidisciplinar research program to investigate the ecological, economic, political, and social implications of using wood as a basis for producing electricity in Michigan.
APPROACH: State and federal agencies, forest industry, university faculty, and the public will be asked to help determine significant questions that should be addressed. individual study proposals will then be developed, coordinated, and submitted to interested agencies for funding.
SUPPORTED BY Michigan State Government

5.0028,
WOODBURNING PRESENTATION DEVELOPMENT AND IN-SERVICE WORKSHOPS

Unknown, Special Intermediate School District 916, *3554 White Bear Ave., White Bear, Minnesota* 55110 (VTP-3265)
Objectives are to (1) develop a presentation and course on use of wood as an alternate fuel; (2) develop slide presentations which correlated with above course; (3) furnish 38 copies of slide presentation, complete with trays, cassettes, and scripts; and (4) provide two regional workshops for inservice of AVTI instructors as selected by Adult Vocational Directors. A consultant will be hired to develop materials and scripts and present the workshop. MIMC will provide technical assistance in developing slide presentations and reproduction thereof.
SUPPORTED BY Minnesota State Government

5.0029,

THE STUDY OF FOREST STAND DYNAMICS BY MEANS OF SIMULATION MODELS

D.W. Rose, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, McIntire Stennis Program, *St. Paul, Minnesota* 55101 (MIN-42-045)

OBJECTIVE: Identify potential control problems of intensive cultures; evaluate the effect of insect defoliation on stand development, growth and yield; analyze the economic feasibility of intensive cultures and define optimal harvest, cultivation and control strategies; and identify potential production sites for intensive cultures with respect to yields, mechanization and markets.

APPROACH: A stand growth simulation model will be expanded to ascertain the reduction in photosynthetic surface as a result of defoliation by the modeled insect population. These simulated values will be incorporated into an ongoing study of the economic feasibility of intensive cultures. Identification of potential production sites will be used to define production categories with similar potential for economic development through multivariable techniques such as cluster profile and canonical analysis.

PROGRESS: Work on an individual growth model for aspen was completed. A regional economic impact study was initiated. State-owned aspen and red pine covertypes in Forest Survey Unit 1 in Northeastern Minnesota will be projected over 3 ten-year periods with and without recommended silvicultural stand treatments using the FREP growth model developed by the North Central Forest Experiment Station. Model modifications have been completed. Regional impacts will be simulated using a regional input-output model. A study of the wood-energy potential of Northern Minnesota was initiated. Biomass inventory data, biomass distribution and harvesting costs will be assembled. A forest sampling simulator was developed for simulation of major plot sampling procedures. A discrete stage, continuous state dynamic programming solution to a thinning problem in even-aged stands was devised.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Minnesota

5.0030,

IDENTIFICATION AND DEVELOPMENT OF HIGHEST VALUE USES FOR THE TOTAL TREE BIOMASS

S.A. Sinclair, University of Minnesota, St. Paul Campus, School of Forestry, McIntire Stennis Program, *301 Green Hall, St. Paul, Minnesota* 55108 (MIN-43-066)

OBJECTIVE: Determine total volume and weight of wood harvested by species and final use category; then of the total biomass harvested, the proportion used for sawlogs, wood fiber, energy and miscellaneous products will be determined along with the amount left in the woods and the amount of bark. Analyze the economic feasibility of utilizing presently unused biomass.

APPROACH: Data describing the total harvested volume of forest biomass by species, final use category, and geographic location will be compiled. Following the basic data analysis, target species and industries will be selected on the basis of the relative amounts and concentrations of unused biomass, and alternative methods of utilizing the unused resource will then be studied.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Minnesota

5.0031,

CHEMICAL AND MICROBIOLOGICAL PRETREATMENT OF CELLULOSIC MATERIALS TO INCREASE ITS ACCESSIBILITY

G.D. McGinnis, Mississippi State University, Mississippi Forest Products Utilization Lab., McIntire Stennis Program, *102 Experiment Station Bldg., Mississippi State, Mississippi* 39762 (MIS-0657)

OBJECTIVE: Develop a more efficient and economical method for increasing the accessibility of cellulosic materials.

APPROACH: Cellulosic material will be treated with a variety of chemical and biological pretreatments. The effectiveness of each pretreatment will be determined by comparing the rates of acid and enzyme hydrolysis, the molecular weights and the crystallinity to those of the non-treated starting material.

PROGRESS: Earlier studies had indicated that hydrogen sulfide gas was able to penetrate the crystalline areas of the cellulose molecule and reduce its crystallinity. More recently studies have indicated that molecular oxygen in the presence of sodium hydroxide is also very effective in reducing the crystallinity of the cellulose. This reagent also converts the cellulosic material into water-soluble products. In experiments with loblolly pine bark and wood, over 90% of the wood and bark was converted into water-soluble products under relatively mild temperatures (300-400 degrees F). The major products which are formed from the wood or bark are organic acids which appear to be produced by reverse aldol-type condensation and by oxidation. Presently we are determining how various parameters such as temperature, base concentration, oxygen pressure and time affect the yield of the final products. This work will be funded by a grant from the Solar Energy Research Institute.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Mississippi

5.0032,

ECONOMIC OPPORTUNITIES & CONSTRAINTS TO IMPROVING PRODUCTIVITY ON PRIVATE NONINDUSTRIAL FORESTS

J.E. Moak, Mississippi State University, School of Forest Resources, McIntire Stennis Program, *102 Experiment Station Bldg., Mississippi State, Mississippi* 39762 (MIS-0689)

OBJECTIVE: 1) Identify constraints which limit adequate provision for regeneration on pine sites after harvest on private nonindustrial forest lands; 2) develop recommendation to remove constraints in item 1) above; 3) develop and energy wood supply curve on private nonindustrial forest ownerships.

APPROACH: Sixty sample properties within each of four counties will be randomly drawn within size of ownership strata from the population of owners who have harvested timber within the past five years. The land will be inspected for proper regeneration, personal characteristics of the owners and their management strategy for the land. Thirty sample properties within each of 4 counties will be randomly and proportionally drawn within size of ownership strata. A field inventory, to include currently non-mechantable wood, will be made of each property and each owner interviewed to determine his asking price for this timber by classification. From this a landowner energy wood supply curve will be developed.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Mississippi

5.0033,

KILN-DRYING PROPERTIES, HEARTWOOD COLOR FORMATION & CHARCOALING CHARACTERISTICS OF NATIVE WOODS

E.A. McGinnes, University of Missouri, Columbia Campus, School of Forestry Fisheries & Wildlife, McIntire Stennis Program, *130 Jesse Hall, Columbia, Missouri* 65201 (MO00174)

OBJECTIVE: Kiln-drying studies of native species (emphasis on drying properties of various abnormal wood formations); discoloration (in service) and/or due to injury and development of normal heartwood coloration for selected native species, and shrinkage and micropore formation resulting from transformation of wood into charcoal under varying conditions of batch kiln operations in Missouri-type charcoal kilns.

APPROACH: With objective 1; sample material will be obtained either from trees exhibiting results of environmental mishap or treatment or else from specific industry where a particular problem exists. Existing techniques, or modifications thereof, will be utilized wherever possible for work under objectives 2-3. For objective 3 SEM, X-ray, and image processing procedures will be utilized to describe ultrastructural change in transformation of wood into charcoal.

PROGRESS: Shrinkage, mass loss, and density data for ten wood species upon charring under a wide range of temperature conditions have been obtained and a publication released. Microscopic (anatomical) changes in white oak (Quercus alba, L.) upon transformation into charcoal have also been published. Results of these studies provide a better basis for understanding what happens when wood is converted to charcoal. Additional information on ash content and cell-wall porosity changes during charcoaling are being obtained. These additional data are important in understanding certain chemical uses of charcoal such as filtration and purification. Color and figure characteristics of commercially prepared black walnut veneer obtained from trees grown on three difference sites in Missouri are being obtained. In addition, genetic influence on color properties of black walnuts is being studied. Color attributes are important factors in governing the price of fine hardwood veneers.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Missouri

5.0034,

IMPROVING WOOD RESOURCE UTILIZATION IN THE INTERMOUNTAIN WEST

R.L. Barger, U.S. Dept. of Agriculture, Forest Service, Intermountain Forest & Range Experiment Station, Forestry Sciences Lab., *Missoula, Montana* 59801 (INT-3251)

OBJECTIVE: Facilitate the harvesting and utilization of underused timber resources in the Rocky Mountain, including small timber, dead and cull trees, mixed material from salvage operations, and residues from harvested areas.

APPROACH: The research program will direct the modification of existing harvesting and utilization technology and practices, and the development and evaluation of new concepts, to accomplishing improvement in utilization of the total available wood resource. Recovery of low-value and residue material for energy uses, and for utilization in the manufacture of conventional wood products, will be the focus of the research. Specific areas of investigation will include: Development and evaluation of harvesting technology that can facilitate economic removal of small or low-value timber; development of efficient handling, sorting, and pre-processing methods for utilization of small or low-value material; identification of technically and economically feasible product, process, and market opportunities; and identification of the role and environmental implications of timber harvesting as a multi-resource land management tool.

PROGRESS: Unused forest residues, including extensive volumes of dead timber, constitute a major potential resource. As much as one-half the cubic volume in old-growth lodgepole pine stands may be deadtimber, much of the so-called resit entirely sound. Small stems and harvesting residues make up additional volumes. Much of the so-called residue resource is suitable for conventional sawn and roundwood products, while the remainder is suited to chip, fiber, or energy generation uses. The manner in which timber is harvested significantly influences almost all aspects of the forest ecosystem--microclimate, nutrient availability, microbiology of the site, insect and disease activity, hydrology, and esthetic quality. Intensive utilization can influence forest microbiology, for instance, reducing populations of mycorrhizal fungi which are essential to the establishment and growth of seedlings. Over 90% of all mycorrhizal activity is found in the humus and litter soil fractions, on sites studied to date. There is also evidence that removing older down material eliminates a primary site for bacterial action important to the nitrogen cycle. Level of utilization can also influence nutrients levels and flows in the forest ecosystem. (Text Truncated - Exceeds Capacity)

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Intermountain Forest & Range Experiment Station

5.0035,

HABITAT-TYPE CLASSIFICATION OF PINYON-JUNIPER WOODLANDS IN THE GREAT BASIN

S.V. Cooper, University of Nevada, Reno Campus, Agricultural Experiment Station, *Reno, Nevada* 89507 (NEV00650)

OBJECTIVE: Construct an ecological classification of the pinyon-juniper woodland and adjacent shrublands of the Great Basin with an emphasis on the type as it occurs in Nevada and provide a practical accompanying key to facilitate use of the classification scheme; other goals are to define biotic potential of the classification units in terms of tree growth, understory production, and other parameters; begin to relate management applications and problems to the units so that the relative success of management systems can be predicted.

APPROACH: Standard community analysis will be undertaken with permanent plots (50 x 20m.) inventoried for overstory and understory composition and coverage and environmental parameters recorded (e.g. geological substrate, landform, soil profile, elevation, etc.). All data are to be stored in a computer bank and similar stands grouped using association analysis to produce a classification.

PROGRESS: The project was subdivided into two substudies. Substudy I was designed to study tree biomass and growth rates in Pinyon (Pinus monophylla) and Juniper (Juniperus osteosperma) in the Great Basin. Tree production was studied in a total of 58 plots of which 48 are complete. Models were developed and applied to the various stands as a first attempt to predict (1) total biomass, (2) nonphotosynthetic biomass, (3) cord wood biomass, (4) fire fuel biomass, and (5) leaf biomass. For the first three of these growth has been determined. Both basal area and crown area biomass predictors are being

developed for pinyon and juniper. No single site variable has been found to be highly predictive. Substudy II is quantitatively describing the differences in shrub, grass and forb biomass in various successional stages of three principal shrub habitat types (Artemisia tridentata/Agropyron spicatum, Artemisia nova)Agropyron spicatum and Artemisia arbuscula/ Agropyron spicatum). Numerous site variables are being related to biomass (site productivity) and succession for these shrub stands located in and near the pinyon-juniper woodland. A technique is being developed for estimating shrub production from annual ring analysis. A total of 16 stands have been sampled for biomass. An inferential approach is being used to describe succesionable variability within the three habitat types.
SUPPORTED BY Nevada State Government

5.0036,
IMPACT OF THE CHANGES IN MARKETING CHANNELS ON THE NEW HAMPSHIRE AGRICULTURAL SECTOR

R.A. Andrews, University System of New Hampshire, University of New Hampshire, Inst. of Natural & Environmental Resources, *Pettee Hall, Durham, New Hampshire* 03824 (NH00220)
OBJECTIVE: Describe service areas of farm supply marketing firms; describe service areas of farm product marketing firms; relate farm firms to input and product marketing firms, develop flows of farm products through market channels and evaluate assembly and distribution functions; enumerate marketing practices that influence market availability; evaluate adequacy of markets and market channels for meeting current and prospective needs.
APPROACH: Information on farm supply firms and product marketing firms and the necessary data relating farms to these firms will be developed from state records, other secondary sources and from survey methods. Flows through marketing channels will be developed and routing systems evaluated by available computer programs. Marketing practices will be determined and assessed on economic efficiency criteria including alternative marketing systems.
PROGRESS: The marketing system for fuel wood has changed, and, based on vendors' comments, will continue to change. There is a developing specialization in services performed in which one operator cuts long logs, and delivers to a retailer who processes the wood into ready for stove size sticks. The fuel wood market in 1977 was characterized by a large number of very small volume vendors, who in total handled a relatively small amount of wood. Most of the fuel wood was supplied by firms and persons whose occupational class was associated with wood industries and farms. About 15% of the fuel wood passed through a middleman; direct sales from producers to consumers was the predominant market channel. By-products of wood milling operations accounted for 15% of fuel-wood sales. A study of sales in individual roadside agricultural produce markets revealed hour of the day, day of the week, and seasonal sales patterns. All markets experienced higher sales on at least one or both weekend days at least for part of the season. Sweet corn in August and bedding plants in May and June followed the total weekly sales pattern of high weekend sales. Most sales were made between 10:00 a.m. and 6:00 p.m. Average dollar value per sale per customer varied by hour of day and day in season. Seasonal variation in sales was pronounced. Fruits, often shipped in, were about 30% of total sales.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New Hampshire

5.0037,
TIMBER VALUES AND HARVESTING COSTS IN CENTRAL NEW HAMPSHIRE

B.B. Foster, University System of New Hampshire, University of New Hampshire, Inst. of Natural & Environmental Resources, McIntire Stennis Program, *Pettee Hall, Durham, New Hampshire* 03824 (NH00014-M)
OBJECTIVE: Develop general guideline for cost estimations of various logging methods, including emphasis on fuel requirements. Develop instructions for applying the 3-P technique to New England commercial timber species. Develop computer-oriented decision-making models using above information.
APPROACH: Make time studies of logging operations using various logging methods under various stand, weather and topographic conditions. Special attention given to fuel requirements (hay and grain in addition to petroleum products). Make laboratory and field applications of Grosenbaugh's 3-P technique of volume and value determinations. Follow selected, measured trees through the milling process to determine accuracy of the predicting regressions. Review existing computerized decision-making models, converting the more applicable into actual computer-programmed tools which would be perfected for use by decision-making field foresters. Make field studies (case studies) in order to compare the usefulness of the resulting tools when used in conjunction with information generated in 1 and 2 above.
PROGRESS: Residual forest stands on areas that were harvested for products including fuelwood averaged 35 acres. These residual stands are sufficient to produce another forest crop and the quality will be above that which was harvested. Managed forest stands are mostly being converted to pure softwoods but unmanaged forest stands have greater residual basal area in hardwoods. The harvesting has improved the total woodlot by adding diversity of habitat for wildlife and more access for recreation while maintaining aesthetic quality. The residual basal area after cutting averaged 71 sq./ ft./ on forestry cuttings and 50 sq./ ft. on non-forestry practice cuttings.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New Hampshire

5.0038,
IMPROVED UTILIZATION OF WOOD (LIGNOCELLULOSE) THROUGH MICROBIOL GENETICS

D.E. Eveleigh, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, McIntire Stennis Program, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (NJ00504)
OBJECTIVE: Increase the potential of wood as a renewable base for the production of fuels and petrochemical substitutes through construction of a series of hyper-lignocellulolytic, catabolite repression resistant and end product inhibition resistant mutants of white rot fungi.
APPROACH: A series of selective plate screening assays will be developed to screen for hyperenzyme secreting mutants of white rot fungi for the enzymes involved in cellulose and lignin degradation. Mutant organisms will be characterized with emphasis on the role of cellobiose; quinone oxidoreductase as the key enzyme in the cometabolism of lignin and cellulose. Genetic crosses will be made utilizing the sexual stage of the fungus to improve strains and determine genetic linkages. Somatic cell hybrids will be obtained by protoplast fusion of white rot mutants as well as Trichoderma reesei mutants in a continuing effort to select superior lignocellulolytic strains.
PROGRESS: Ethanol is a prime candidate as an alternate transportable fuel of the furture. It may be obtained by enzymatic conversion of woody substrates by cellulose to glucose, with fermentation of the latter to ethanol. We are exploring the possibilities of selecting microbes that efficiently convet cellulose and lignocellulose to useful chemical feedstocks. This recently initiated project has focused on a study of an enzyme, cellobiose quinone oxidoreductase, which links the degradation of cellulose to lignin. Phanaerochaete chrysosporium is the source of this enzyme. Initial preparation and purification of the enzyme has begun.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New Jersey

5.0039,
ECONOMIC CHARACTERISTICS OF FUELWOOD HARVESTING IN NEW MEXICO

J.R. Gray, New Mexico State University, Las Cruces Campus, Agricultural Experiment Station, McIntire Stennis Program, *University Park, Las Cruces, New Mexico* 88003 (NM00020MS)
OBJECTIVE: Determine fuelwood supplies, present and predicted, by species by key and harvested supply areas of New Mexico; measure investments and costs of fuelwood harvesting by both dealers and consumers harvesting their own wood; ascertain the socio-economic characteristics of fuelwood users, and construct fuel energy budgets indicating net gains or losses in harvesting fuelwoods in various areas.
APPROACH: Data from Federal Forest Service and State Forestry dealing with fuelwood supplies and harvests will be tabulated and related to fuelwood management policies. Historical trends in fuelwood production and use will be determined from published data, and projected to 2000. Individuals issued cutting permits will be tabulated, a sample drawn and a mail questionnaire sent to the selected samples. Personal interviews will be made of chainsaw dealers. The mail questionnaire will deal with investments, costs, and fuel uses as well as socio-economic characteristics and characteristics of wood burning units. Analyses will include statistical projections of supply and demand, and cost and energy budgets.
PROGRESS: U. S. Forest Service Regional Office, each Forest Supervisor's office, and all ranger district offices in New Mexico were contacted and approximately 5,000 individuals who had requested either fuel use or commercial cutting permits were tabulated. In districts where free use records were inadequate, chain saw inspection records were used. District rangers and their staffs were interviewed to determine estimated acreages and quantities of fuelwood available by species. Other researchers engaged in fuelwood studies were contacted and information was exchanged. Initial contacts were made with officials in the Bureau of Land Management and New Mexico Department of State Forestry. The latter agency is in the process of accumulating statistical supply information. Shortages of fuelwood supplies were recorded in the low income area of northcentral New Mexico and near Albuquerque. A tense situation has developed in the former area between local residents using fuelwood as a major energy source in their homes, and non-local residents seeking fuelwood mainly for esthetic purposes or resale, Unauthorized cutting frequently occurs on BLM lands in the area. One graduate research assistant has been employed on the project.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New Mexico

5.0040,
WOODBURNING PLANT-VISIBILITY

E.M. Leonard, U.S. Dept. of Energy, Los Alamos Scientific Lab., *P.O. Box 1663, Los Alamos, New Mexico* 87544 (W-7405-ENG-36)
The objectives are to determine the effects on visibility of woodburning power plants and compare these effects with those of coal and oil for similar size plants, and to document the basic characteristics of woodburning plants including stack heights, temperature and velocity of emissions, composition of emissions and meteorological conditions at the plant site. A number of actual plant studies at both existing and proposed sites will be conducted. Photographs of actual emissions will be compared with computer generated photos of the emissions. Both long range transport effects and short range dispersion will be considered. The project includes model development and model verification.
SUPPORTED BY U.S. Dept. of Energy, Office of Energy Technology

5.0041,
PRODUCER GAS AS A PETROLEUM SUBSTITUTE

W.W. Gunkel, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123423)
OBJECTIVE: Critically examine the known technology of making producer gas; determine the feasibility of using this technology to reduce the dependence of agriculture in the Northeast on conventional fuel sources; design, construct and test a producer gas system including: Gas generator, filter, heat exchanger, fine filter and engine; prepare a summary report of the study including an economic analysis of producer gas substitution for conventional fossil fuels and electricity.
APPROACH: The first phase of this study will be to determine an optimum size of the producer gas generator. Then a gas generator will be designed, constructed and tested. After completing the tests, the generator will be connected to a filtering and heat exchanger system and finally to an internal combustion engine. Operational characteristics of the system will be measured and any particular problems identified and corrected.
PROGRESS: Investigations of the use of producer gas for both motor vehicle and heating fuels were started. A thorough review of literature relating to producer gas use and generator designs was completed. Surveys have been completed to determine the potential quantity and availability of producer gas fuel - primarily wood - in New York State. A small producer gas generator and associated equipment has been designed and is partially constructed. When completed the producer gas generator will be used to provide fuel for a small internal combustion engine. Information obtained from power output versus airflow, hearth temperatures, and other parameters will be used to design an automatic control systems for producer gas generation and utilization.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New York

5.0042,

RESOURCE INVENTORY AND ANALYSIS FOR FOREST LAND USE PLANNING

L.S. Hamilton, Cornell University, Ithaca Campus, Agricultural Experiment Station, McIntire Stennis Program, *Ithaca, New York* 14850 (NYC-147552)

OBJECTIVE: Evaluate the usefulness of various kinds of natural resource information, how it may best be obtained and how it may be used in multiple use planning for forest and wildlands, and in determining alternate uses of forest lands. Study the impacts of selected resource uses on forest and related lands through resource inventory and analysis.

APPROACH: Through a senes of sub projects: Develop a method of biophysical land classification which is integrated with economic and social considerations to guide programs and land uses on upper watersheds where low technology inputs are appropriate. Consider the land use and environmental effects of high, extra high and ultra high voltage transmission lines on forest and related lands, and the methods of securing resource information for location planning. This will be based on previous work under this project. Assess the extent to which biophysical parameters have historically affected forest land use.

PROGRESS: A rapid, low cost method of forest land assessment and capability classification has been developed. It combines the Holdridge life zone bioclimatic classification with the identification of landscape units which are recognizable on airphotos, and which are relatively homogeneous with respect to geology, soils, topography and vegetation. Based on the assumption that these units will tend to respond in similar fashion to the same kind of treatment, capability potentials were rated for timber and fuelwood production, protection function, reforestation, grazing and seven kinds of commonly raised agricultural crops. This was done for a 160,000 hectare watershed in Venezuela in two man years (approx. $45,000), roughly 23 cents per hectare. The methodology has been welcomed by the Venezuelan government which will run training schools. The method will be publicized by an article in an international journal, and at a symposium on forest land assessment to be held in June 1979 at the East West Center in Hawaii.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New York

5.0043,

USE OF FORESTS FOR FOOD AND FIBER

R.R. Morrow, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Natural Resources, *Ithaca, New York* 14850 (NYC-147412)

OBJECTIVE: Develop biological and value growth data from thinning typical forest stands in New York. Develop long-term (15 years) sap flow and temperature data for two widely different geographical areas, and complete applied research on preheaters. Complete and publish long-term studies (above).

APPROACH: remeasure trees by standardized procedures for growth. Analyze stand growth data. Review wood charactenstics and fuel literature; apply to New York forest conditions. Keep yearly standardied records of sap flow, weather, and energy use at research stations. Seek relationships and publish results.

PROGRESS: Major investigations of fuelwood potential for both homes and industry were made. Energy and efficiency relationships of different fuels are often incorrectly reported or undefined in the literature; research is needed. A senior Practicum concentrated on the feasibility of using wood fuel to heat Cornell University. A major finding is that wood, a renewable resource compared to fossil fuels, can be more efficiently used in large industrial plants than in the home. For home use wood is 'dirty' (for firing and ash removal), often inefficient (wide variety of stoves of unknown and often poor efficiency), and costly (handling, splitting, etc.). For industrial use wood is clean (no problems with SO(x) or NO(x), as with coal), can be efficient (large, high temperature furnace), and potentially cheap (mechanization and large volumes - trasport, chipping,and handling). This suggests more efficient allocation of scarce resources. Two hardwood thinning plots were remeasured and long term sap flow records were continued at two stations. Evaporator efficiency studies were continued.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New York

5.0044,

FIREWOOD ASSISTANCE FOR THE ELDERLY

Unknown, New York State Government, *1215 Western Ave., Albany, New York* 12203 (NY-6171-78-I-302-0531)

There are four principal goals of this demonstration: (1) Assist low-income residents in obtaining adequate amounts of quality wood for home heating; (2) Assisting low-income residents in reducing their home heating costs by use of local timber supplies; (3) Development of a mechanism that will assure adequate supplies of wood for home heating purposes that will be economically self-sufficient; and (4) provide assistance to low-income residents in use of wood for home heating.

SUPPORTED BY U.S. Appalachian Regional Commission

5.0045,

CONTINUATION OF NORTH CAROLINA WOOD FOR ENERGY GRANT AGREEMENT

Unknown, State Energy Div., *Raleigh, North Carolina* (NC-6492-79-C1-302-0406)

This request will provide funding to continue expert technical assistance in the organization of a forest landowners association, continued funding of a professional forester (TDO Manager), benefits, travel, eqquipment, supplies, postage, secretarial services, and office expenses associated with the grant. Specifically, during this eight-month period, a brochure will be completed and be used to interest landowners in membership; final work will be completed and be used to interest landowners in membership; final work will be completed on a charter, by-laws, and marketing agreements such that incorporation can be expected in June 1979; four to six meetings in each of the four pilot counties will be scheduled and conducted to solicit membership in the organization using listings of the Agricultural Stabilization and Conservation Service and Agricultural Extension Service; surveys will be completed of landowners in the four-county areas; continued development of forest land management plans for members of the Association will be pursued; the TDO Manager will work with the Tennessee Valley Authority to seek cooperative working arrangements for use of computer capacity to assist in forest land management plans; monitoring and general administration of the preparation of pro forma financial statements for the new association will continue (actual preparation is being funded from other sources); financial support will be sought from public and private sources for long-range funding needs based on pro forma financial statements; preparation of applications for grant and loan funds will be completed; and preparation of a final report.

SUPPORTED BY U.S. Appalachian Regional Commission

5.0046,

NORTH CAROLINA WOOD FOR ENERGY CONFERENCE

Unknown, State Energy Office, *North Carolina* (CO-7136-79-I-302-0904)

Under this proposal North Carolina and Georgia would cooperatively conduct a wood energy conference in Appalachian North Carolina. An exact location has not been selected. The theme of the conference is to be Wood Energy: What We Have Learned; Where Are We Going? The scope of the conference will address specific subjects of interest to industrialists, public officials, foresters, landowners, engineers, planners and similar persons producing timber and/or waste wood products or those in a position to potentially use wood as a source of energy. Topics are to include: a history of wood for energy use in North Carolina and Georgia as well as elsewhere in Appalachia (and potentially the United States); technical and engineering aspects of wood conversion of boilers; cost-effective methods of conversion; resource base characteristics; the logistics of wood harvesting, transportation, storage, processing, and utilization; and contracting for wood for fuel and assessing market potentials.

SUPPORTED BY U.S. Appalachian Regional Commission

5.0047,

PARAQUAT STUDIES

Unknown, U.S. Dept. of Agriculture, Forest Service, Southeastern Forest Experiment Station, *P.O. Box 2570, Asheville, North Carolina* 28802

The objective is to develop methods to increase production of naval stores to a magnitude that would lower prices for rosin and turpentine and their derivatives to the point that they would compete with petroleum, natural gas, and coal tar derivatives as chemical intermediates in the production of many kinds of plastics. This substitution would permit more petroleum, natural gas, and coal to be released to satisfy energy needs.

SUPPORTED BY U.S. Dept. of Energy, Savannah River Operations Office

5.0048,

INVESTIGATION OF THE RATE OF THE DECOMPOSITION OF WOOD RESIDUE FUELS

D.C. Junge, Oregon State Higher Education System, Oregon State University, School of Engineering, Dept. of Mechanical Engineering, *200 Covell Hall, Corvallis, Oregon* 97331

This is a study of the rate of combustion of wood residue fuels in a combustor under various conditions of feed rate, air rate, and quality of combustible material. A detailed investigation of the processes occurring in the combustion process will be performed. The principal types of combustion systems used for this study are the spreader stoker and the fluidized bed. A data base for production of a handbook on spreader stoker burners for boiler applications will be produced.

SUPPORTED BY U.S. Dept. of Energy, Office of Fossil Energy

5.0049,

HARVESTING SMALL LOGS AND RESIDUE WITH SKYLINES

D.E. Aulerich, Oregon State Higher Education System, Oregon State University, School of Forestry, McIntire Stennis Program, *126 Agricultural Hall, Corvallis, Oregon* 97331 (ORE-F-00053)

OBJECTIVE: Test prebunching as a means of increasing the efficiency of thinning. Test downhill yarding over intermediate supports. Determine costs of yarding residue with large and small yarders. Compare costs of hauling chipped and unchipped residue. Determine falling, bucking and yarding of hardwoods for energy production.

APPROACH: Conduct production analyses of harvesting systems during operations. Develop relationships to predict costs and production. Develop a simulation to estimate costs and benefits of harvesting and handling forest residues for energy production.

PROGRESS: Three studies were completed during 1978: hardwood and brush removal with a small skyline yarder; prebunching with a small yarder and swinging with a larger yarder; yarding downhill in a thinning with the small yarder. Mechanical removal of hardwood logs and brush with a cable machine does not seem to be a viable alternative to herbicides for improving young stands. Costs were prohibitive at $1127/acre. The field work for the prebunching study has been completed. Four skylines were prebunched (logs pulled laterally and piled in the skyline corridor) with the trailer alp yarder for swinging with a West Coast tower. Nine hundred prebunching turns and three hundred fifty swing turns were measured and recorded. Two skyline roads were lateral yarded with the West Coast only for a comparison with the two machine system. Three hundred twenty one turns were recorded. The downhill yarding study utilizes a system new to the United States. Production rates and costs will be evaluated over a range of conditions. Yarding tree-length pieces will be compared to yarding logs. The system utilizes the Trailer Alp Yarder with intermediate supports.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Oregon

5.0050,

ENERGY UTILIZATION OF LODGE POLE PINE RESIDUES

R.E. Currier, Oregon State Higher Education System, Oregon State University, School of Forestry, Dept. of Forest Products, *126 Agricultural Hall, Corvallis, Oregon* 97331 (ORE-F-00044)

OBJECTIVE: Prepare a working plan document under funding by the U.S. Department of Energy, for use by the Department and the U.S. Forest Service to identify methods of utilizing dead timber and forest residues as an alternate energy source in the study area.

APPROACH: Determine the type, volume and location of the raw material; analyze feasible methods of harvesting, handling and transporting the raw material; specify potential methods for utilizing the raw material to produce energy; analyze economic,

social, and political consequences of alternate systems for utilizing the material.
PROGRESS: The Blue Mountain region of Oregon and Washington contains an estimated 15 million tons of dead or drying pine timber killed by an infestation of the mountain pine beetle. In addition, available annually is at least another one half million tons in the form of normal logging residues. All of this material is a potential fuel for energy production. Our report provides a working plan or 'road map' to outline research and demonstration projects to study use of the available forest biomass for production of energy. The task was divided into four topics, each with an assigned investigator, who reviewed the current literature and offered recommendations. Several demonstration and research projects are suggested in the harvesting and raw material transportation section of the working plan. Included are such items as mechanized logging technology, layout of optimal cutting units, evaluation of smallwood cable systems, evaluation of alternatives to in-woods processing and conventional hauling methods, and measurement of fuel consumption during harvesting. Possible methods whereby the Blue Mountain forest resource would be converted to energy should include a sorting yard demonstration where incoming raw material could be assigned to its highest economic product value, be it saw logs or hogged fuel.
SUPPORTED BY Oregon State Government

5.0051,
FOREST RESIDUES PROGRAM

E.H. Clarke, U.S. Dept. of Agriculture, Forest Service, Pacific Northwest Forest & Range Experiment Station, *P.O. Box 3141, Portland, Oregon* 97208 (PNW-2107)
OBJECTIVE: Direct a major RD&A Program effort towards developing practical and environmentally acceptable solution to the critical forest residues problems in the Pacific Coast States.
APPROACH: Aim efforts at developing guidelines for improved residue management planning capabilities. This will involve finding methods of predicting amounts of slash created by an activity and developing guides for specifying desired levels of residues; determining both long-term and transitory environmental effects of residues and an array of treatments, including prescribed underburning in partial-cut stands on steep slopes, exploring means of reducing residues through timber sale arrangements and harvesting techniques; and finally, refine and adapt decision frameworks for determining the 'best' treatment from among alternatives. Strong emphasis will be given to transferring new technology to user groups.
PROGRESS: This Research, Development and Application Program is continuing efforts to provide the land manager with tools, techniques, and methods necessary to integrate residues requirements into forest land management planning. Management techniques and sales arrangements are being developed to aid land managers in establishing desired residue levels and then to aid in attaining such levels through choice of the optimum residue treatment. Forest residue management guidelines were completed for both public and private forest lands in Pacific Northwest. Training sessions on application is in progress to help meet management objectives with best available technology.
SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Pacific Northwest Forest & Range Experiment Station

5.0052,
FOREST BIOMASS AS A SOURCE OF ENERGY AND BY-PRODUCTS

P.R. Blankenhorn, Pennsylvania State University, University Park Campus, School of Forest Resources, McIntire Stennis Program, *102 Ferguson Bldg., University Park, Pennsylvania* 16802 (PEN02173)
OBJECTIVE: Determine the feasibility of using forest biomass as fuel for generating delectrcity for small-sized communities (10,000) or manufacturing firms in Pennsylvania, and the by-products from alternative processes.
APPROACH: This study will extensively evaluate the literature to assess the known technology of utilizing biomass directly or indirectly as a fuel source. In evaluating the alternative methods for using wood as a fuel source, value of the by-products will be considered. This study, in general, will examine existing sources of wood in Pennsylvania necessary to keep one 100 MW power plant going indefinitely. As a spin-off the literature will be examined to determine the problems associated with utilizing the forest biomass directly or as the raw material for products to be used as the fuel source for an electric generating plant.
PROGRESS: A method was established for evaluating the feasibility of using wood as a fuel source for an electric generating plant. The parameters investigated include forest biomass availability, site considerations, biomass conversions, and energy balance. Energy inputs were analyzed particularly with respect to production, harvesting, processing, and transportation of the biomass. These energy inputs wre balanced against the potentially recoverable energy to obtain net energy values. This study examined factors associated with biomass production, biomass in terms of growing stock, residues available from commercial operations, and biomass conversion into energy, char and gaseous products. Energy systems that may be available in the future for conversion of biomass to gaseous or liquid fuel were also briefly presented.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Pennsylvania

5.0053,
WOOD AS AN ENERGY SOURCE IN THE RURAL-URBAN COMPLEX

W. Could, University of Rhode Island, Agricultural Experiment Station, McIntire Stennis Program, *Administration Bldg., Kingston, Rhode Island* 02881 (RI00960)
OBJECTIVE: Determine the potential demand for fuelwood in the southern New England rural-urban complex. Evaluate the productivity of typical sites for growing fuelwood. Assess ways to more efficiently use the resource by determining practical methods of seasoning wood.
APPROACH: Several even-aged stand sites will be selected to include well-drained, moderately well-drained and poorly drained locations. Cordwood biomass productivity of each stand will be determined by sample plots. Individual trees will be randomly selected by diameter-class for distructive sampling. Root systems of several sample trees will be examined for sprout vigor and tree origin. Fertilization to increase growth rates will be evaluted. Trends in fuelwood consumption will be determined. various aspects of wood seasoning will be investigated.
PROGRESS: Fuelwood biomass was determined for well drained and moderately well drained site categories. Three study areas were delineated from each drainage category and a total of 12/0.0405 ha plots were established for such standard tree measurements as dbh, basal area and total heights. Two hundred trees, selected according to dbh classes were cut and the bole and branch wood to a minimum diameter of 2.54 cm were weighed fresh. Two hundred sample disks taken from various heights of each tree stem, were weighed fresh and then weighed oven-dry. A complete soil analysis was conducted for each soil drainage category. Plot, soil and tree data were analysed. Interpretation is incomplete; preliminary results indicate that some 40 year old mixed oak coppice stands produce nearly a cord of wood per acre per year. Oak fuelwood drying is being studied in regard to effect of time of cutting and degree of weather protection. Wood samples are placed in drying racks (0.27 mue3 capacity) and periodically weighed to determine moisture content. At this time, six racks (N=12) have been filled and are being monitored. Data on fuelwood demand have been collected and analyzed by telephone survey. Results indicate that 23% of urban/urban-suburban households and 48% of rural/rural-suburban households burned firewood during the study season. Households heating with electricity as the primary heat source used more than did users of fuel oil or natural gas.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Rhode Island

5.0054,
RHODE ISLAND INTENSIVE FOREST MANAGEMENT AREA PROJECT

W.P. Gould, University of Rhode Island, Agricultural Experiment Station, *Administration Bldg., Kingston, Rhode Island* 02881 (RI-RD-3)
OBJECTIVES: Educate the small Rhode Island forest landowner as to the production potential of the common forest types and appraise him of intensive management procedures that are consistent with landowner objectives and aesthetic considerations. Landowner management objects are maximum fuelwood production and/or integrated optimum product management.
APPROACH: Establish three research/education intensive management plots to show production potentials and appropriate management techniques. The plots will be analyzed, marked and harvested to illustrate goals and procedures. Workshops will be held for small landowners and youth group workers (4-H leaders and teachers). Publish extension educational publications relative to these and other research findings. Evaluate the research and educational aspects of the project.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Rhode Island

5.0055,
COOPERATIVE FOREST MANAGEMENT RESEARCH

Unknown, E.I. du Pont de Nemours & Co. Inc., *P.O. Box A, Aiken, South Carolina* 29801 (EY-76-A-09-0056)
The production of naval stores (rosin and turpentine) is an important resource output from southern forests. Currently over one billion pounds annually go into such major end uses as rosin for paper size, synthetic rubber, adhesives, surface coatings, printing ink, synthetic pine oil, insecticides, pressure sensitive tapes, flavors and fragrances. It has been recently discovered that wounding and treatment of trees with the herbicide paraquat will induce increased oleoresin production. Increased production could lower prices and stabilize supply of rosin and turpentine and their derivatives to the point that they could compete with petroleum, natural gas, and coal tar derivatives as chemical intermediates in the production of many kinds of plastics. This substitution would allow more fossil fuels to be released to satisfy energy needs. Oleoresins themselves could also be converted to fuels.
SUPPORTED BY U.S. Dept. of Energy, Office of Health & Environmental Research

5.0056,
BIOMASS UTILIZATION FOR INDUSTRIAL POWER PRODUCTION IN THE APPALACHIAN REGION OF SOUTH CAROLINA

Unknown, South Carolina Energy Research Inst., *1401 Main St., 1st. Natl Bank Bldg. Suite 670, Columbia. South Carolina* (CO-7135-79-I-302-0831)
The South Carolina Energy Research Institute (SCERI) submitted a request for ARC funding, from the energy allocation, to assist in funding a detailed analysis of the capacity of the most forest biomass in six South Carolina Appalaccian counties to sustain initiative to utilize forest products as an alternative to conventional sources of energy. A favorable analysis would be a basis for Clemson University making a subsequent conversion of one of its boilers to wood for energy, at no expense to ARC. Specific tasks to be performed include the following: a. An inventory of the area's industrial group requirements and fuel usage and asses local industries' capability and interest in converting wood or wood products as an alternative energy source. To the extent possible, Grantee will use local agencies such as the South Carolina Appalachian Council of Governments for this inventory. b. Through the South Carolina State Commission of Forestry, an assessment of the currently available and long-term sustainable production of wood for energy production purposes will be made. The South Carolina State Commission of Forestry is now planning an inventory of 'non-harvestable', i,e., currently non-commercially usable, timber residues in the state. c. In conjunction with task b. above, SCERI, the South Carolina State Forestry Commission and Clemson will collect data on current demands on the forests of the Appalacian Region. d. Information on land ownership, landowner attitudes, land use, and other cultural/institutional factors as they effect forest biomass harvesting will be collected and analyzed. e. An analysis of terrain, economic, enviromental and technical assessment of harvesting methods and in-fluence of slope, highway and rail networks and other factors will be made. f. The information collected in a. through e. above will be integrated into an organized and cross referenced data base, and data will be mapped using remote sensing data available from the LANDSAT program. This will be a new and innovative adaptation in use of LANDSAT. While important elements in any assessment of wood availability must also consider environmental and economic factors, these are to be considered in efforts undertaken in years two and three of this effort by South Carolina.
SUPPORTED BY U.S. Appalachian Regional Commission

5.0057,

MARYVILLE COLLEGE PYROLYSIS PROJECT

E.L. Klein, U.S. Tennessee Valley Authority, Div. of Land & Forest Resources, *Norris, Tennessee* 37828

This project is to make from dry industrial or forest hardwood and softwood residues oil, gas and charcoal. A mobile pyrolysis unit has been obtained for testing. Dry residue enters a reactor chamber where heat is applied. This causes a gas to form which can be burned in a combustion chamber. Or the gases can be routed through a condensor where oils can be obtained, the remaining gases can then be burned to provide heat. If oxygen is restricted from the reactor chamber the wood becomes charcoal after the gases are driven off. The charcoal has a present market value of about $75 per ton.

The present investigative work includes 1) determining temperature and dwell time in the reactor chamber, 2) proper condensing temperatures, 3) btu content of oils and gases obtained at different temperatures, 4) chemical composition of these oils and gases, 5) the commercial application of the mobile unit in both the mobile and stationary mode.

SUPPORTED BY U.S. Tennessee Valley Authority, Div. of Land & Forest Resources

5.0058,

ECONOMICS OF CHIP HARVESTING SYSTEMS IN THE SOUTH

J.G. Massey, Texas A & M University, College Station Campus, Agricultural Experiment Station, McIntire Stennis Program, *College Station, Texas* 77843 (TEX06301)

OBJECTIVE: Identify the market potential for wood chip use in the paper, fiberboard, and energy-related industries in Texas and in the South, determine the level of fossil fuel price at which wood chips become economically feasible for various technologies in chip production, and assess the probable impacts of a wood chip energy market, coupled with the paper and fiberboard markets, on economic returns to the forest landowner and Texas' and the South's future timber supply.

APPROACH: Through literature and survey determine wood input mix to the paper, fiberboard, and energy industrial markets. Survey the off-site chippping technologies. Develop off-site chipping economic data. Survey the on-site chipping technologies. Conduct time studies to define the production functions for the various chipping methods. Develop and test a simulation model to determine the effets of various levels of labor and capital inputs on the chip, energy, and product outputs from the chip harvesting systems.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Texas

5.0059,

CHEMICALS AND ENERGY FROM FORESTRY AND RELATED RESIDUES

E.J. Soltes, Texas A & M University, College Station Campus, Agricultural Experiment Station, McIntire Stennis Program, *College Station, Texas* 77843 (TEX06279)

OBJECTIVE: Identify and address technical and economic constraints in residue utilization. Identify and develop processes for producing chemical and energy products from residues. Evaluate various preprocessing schemes to enhance residue utility in product generation.

APPROACH: Assess and address biomass availabilities; harvesting and transportation problems. Evaluate pyrolysis as a means of generating clean, volatile fuels from dirty residues. Characterize products of pyrolysis of various residues. Identify and develop pyrolysis parameters and post-pyrolysis processing in maximizing yield of useful products and intermediates. Evaluate the effects of composting and other processes on residue utility.

PROGRESS: The characterization of pyroligneous products may permit development for future chemical industries from the biomass base. The Tech-Air pyrolysis oil has been further characterized. New information includes the identification and quantification of the major phenolic components, and confirmation that acetic and formic acid concentrations in the oil are responsible for its corrosivity. It is becoming apparent that utilization of this oil will require prior fractionation to yield fractions with similar chemical or physical properties, or processing to alter the chemical complexity. Current work includes the evaluation of adhesives produced from formaldehyde condensations with the phenolic fraction, and the identification of processing requirements to produce diesel fuel from the oil. Work on the laboratory pyrolysis reactor was delayed, but it is now essentially completed, and the reactor will be used soon in the evaluation of biomass feedstocks for pyrolysis. Laboratory efforts to develop quantitative ligninase test via the syringaldzine reaction were suspended due to lack of progress. Some work has been initiated in differentiating the effects of T. viride cellulase activity vs. rumen microorganism activity on a forage grass. Several reports were written on the biomass residue resources of Texas and their energy potentials, as well as two treatises on pyrolysis.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Texas

5.0060,

FOREST PRODUCTS UTILIZATION

D. Weldon, Texas A & M University, College Station Campus, Agricultural Experiment Station, Dept. of Forest Science, *College Station, Texas* 77843 (TEX06246)

OBJECTIVE: Extend the service life of wood shingles and fence posts. Extend the timber resource through a more complete utilization of wood residues.

APPROACH: Isolate and identify causal agents for early failure of wood shingles and fence posts. Through use of accelerated weathering devices determine most effective preservative treatment for wood shingles and posts. Determine new and expanded uses for wood residues and noncommercial species, both as energy sources and reconstituted products.

SUPPORTED BY Texas State Government

5.0061,

MAPLE PROCESSING EQUIPMENT AND RELATED PROBLEMS

F.M. Laing, University of Vermont & State Agricultural College, Agricultural Experiment Station, Dept. of Botany, *85 S. Prospect St., Burlington, Vermont* 05401 (VT00264)

OBJECTIVE: Investigate modifications to conventional open-pan evaporators which will provide greater economic efficiencies. Investigate and evaluate other processing equipment which might be applicable to maple processing. Investigate quality control performance of units researched for comparison with conventional evaporator output.

APPROACH: Test of automatic feed wood chip fueled maple syrup evaporator. Engineering and cost efficiency of different wood fuel types and implications to equipment modification. Economic and engineering efficiencies of modified preheaters installed on conventional evaporator systems. Engineering and economic efficiency analyses of vapor compression distillation, redesigned for processing sugar solutions. Characterization of flavors and off-flavors with taste panels, chemical and physical analyses, as affected by variables associated with maple syrup products manufacture.

PROGRESS: The tubular sap pan was continued in operation to further test modifications. Further design changes to facilitate fabrication are planned. Wood chip fuel designs are complete. Tests of pelletized wood residue fuel have been delayed pending location of a commercial pelletizing plant. Preliminary work on a 2-stage evaporative system was started. In lieu of a complete installation in situ, sap was evaporated to 10 degrees Brix in the tubular unit, further concentrated to 50 degrees Brix in a dairy type vacuum evaporator located in the Dairy Sciences Building and brought to completion in a gas-fired finishing pan. The product was judged excellent quality. In an integrated system steam from the conventional evaporator would be used as a heat source for the vacuum unit. The tests were run with units of unequal capacities, therefore economic analyses were not feasible but results to date warrant further work. The system should provide significant energy savings.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Vermont

5.0062,

ANALYSIS OF THE FUELWOOD MARKETING AND DISTRIBUTION SYSTEM IN VERMONT

D. Bousquet, University of Vermont & State Agricultural College, School of Natural Resources, McIntire Stennis Program, *85 S. Prospect St., Burlington, Vermont* 05401 (VTZ00036)

OBJECTIVE: Identity and describe the physical structure and function of the existing fuelwood marketing and distribution system in Vermont. This will include definition of producer, product, channel and ultimate consumer characteristics and requirements. Evaluate the economic performance of the fuelwood processing system. This will include analysis processing, efficiency, costs and returns and costs of fuelwood delivered to consumer.

APPROACH: Fuelwood producers: Direct personal interviews and direct measurement of process variables - labor; machine and investment costs for different types of producers. Emphasis on defining organization problems, and characteristics and potentials. Functions include: Fuelwood harvesting, 'manufacturing', inventory, measurement and storage, transportation and delivery. Methods and time study; energy balance; R.O.I.; analysis of delivered cost to consumer. Fuelwood Consumers: Direct personal interviews with cooperating 'urban' and 'rural' consumers, utilizing direct and coded questionnaires. Direct area selection - stratified after sampling. Specify situation regarding species, form, size, volume, seasoning, storage and delivery, seasonal demand; type of end use; pricing; costs.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Vermont

5.0063,

MAPLE SYRUP PRODUCTS MARKETING AND WOOD ENERGY RESEARCH

L.D. Garrett, University of Vermont & State Agricultural College, U.S. Dept. of Agriculture Northeastern Forest Expt. Station, *85 S. Prospect St., Burlington, Vermont* 05401 (NE-4207)

OBJECTIVE: Define wood resource economic availability, growth, harvest, processing, utilization, and market methodologies necessary for economic use of wood fuel for home and institutional space heat, industrial heat and power, and electric generation. And, for maple products industry: Develop effective quality control methodology for improved sap, syrup, and sugar products; develop improved processing systems and develop new products to permit market expansion.

APPROACH: Conduct studies to evaluate existing and projected biomass and existing and projected wood waste from harvesting and processing; develop economic models to relate cost parameters associated with spacial location of wood resource to energy needs of the community and industrial components; compare existing harvesting systems with large and small mechanized chipping systems, small high-lead or sky-line crane logging systems, and specially adapted all-terrain, small integrated logging systems; analyze marketing methods for delivering wood fuels directly or through marketing intermediaries to various end uses; evaluate market implications of differing wood fuels, including solid, chipped, and pelletized wood fuel products; develop economic analysis of wood as an energy alternative for home and institutional space heat, industrial heat, and power and electric generation; develop area, regional, and national profiles on saps and syrups to provide evaluations of factors contributing to the development of color and flavors in syrups and sugars.

PROGRESS: A study of maple sap preheaters or heat exchangers resulted in a parallel flow design that increased sap temperatures to 190-200 F using waste steam from the evaporator. The preheater increases evaporator efficiency by 15 percent and will reduce processing cost about 6 percent and will reduce total production cost about 3 percent. A test of vapor compression distillers for processing maple syrup revealed that vapor compression equipment tested evaporated 1 pound of water with .047 pounds of steam equivalent (electrical energy). Open-pan evaporators of similar capacity required 1.5 pounds of steam equivalent (oil energy) to produce 1 pound of water. Work to detect activated charcoal filtration of pure maple syrup (quality control) by gas chromatography is continuing. Methods of collecting the volatile compounds in maple syrup are being evaluated to obtain the most reliable method.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Northeastern Forest Experiment Station

5.0064,

ENGINEERING AND COMBINATION TEST FIRING-WOOD/CAL PROJECT

Unknown, Quinault-Pacific Corp., *Shelton, Washington* 98584

SUPPORTED BY U.S. Dept. of Energy

5.0065,

HIGH RATE ANAEROBIC TREATMENT OF EVAPORATOR CONDENSATES FROM SPENT PULPING LIQUORS

J.L. McCarthy, University of Washington, School of Engineering, Dept. of Chemical Engineering, *206 Guggenheim Hall, Seattle, Washington* 98105 (B-084-WASH)

A submerged anaerobic filter (SAF) is used to treat evaporator condensates in order to increase internal reuse of process water, to reduce waste treatment costs, and to recover methane gas. Evaporator condensates contain mixtures (2-10 gr/1) of slightly volatile organic compounds, including methanol, acetic acid, furfural, acetone and terpenoid compounds. The treatment systems to be investigated in laboratory scale include packed bed reactors with incorporation of effluent recycle, dialysis modules to add condensate organics, and gas saparators to reduce the partial pressure of carbon dioxide.

The project is intended to develop a technically feasible SAF process and to determine its effectiveness and operating parameters. Other objectives include studies of the removal of specific organic compounds in the process and a process design and economic analysis.

SUPPORTED BY U.S. Dept. of the Interior, Office of Water Research & Technology

5.0066,

DEVELOPMENT OF SYSTEMS MODELS ADAPTABLE TO THE STUDY OF FOREST LAND USE AND FOREST UTILIZATION PROBLEMS IN THAILAND

J.S. Bethel, University of Washington, School of Forest Resources, Dept. of Management & Social Sciences, *115 Anderson, Seattle, Washington* 98195 (INT77-15157)

This award is in partial support of work undertaken by the staff of the College of Forest Resources, University of Washington, to adapt and extend the Tropical Forest Utilization System (TFUS) to develop a rational forest land use program applicable to northern Thailand. The integrating component of TFUS is a Reference Materials System, which uses a series of simulation models to represent the structure of a forest and relevant conversion facilities. The National Research Council of Thailand will support the work of scientists from Kasetsart University in Thailand in this project. Specific work undertaken will include analysis of growth and stand data and development of additional utilization models to incorporate local consumption of wood for fuel and options for producing fuel wood. An introductory phase of this study was supported under NSF award INT 7608937.

SUPPORTED BY U.S. National Science Foundation, Directorate for Scientific Technological & Internat. Affairs, Div. of International Programs

5.0067,

HARVESTING, PROCESSING AND MARKETING OF FOREST PRODUCTS PROGRAM)

G.F. Schreuder, University of Washington, School of Forest Resources, *115 Anderson, Seattle, Washington* 98195 (WNZ-M2-04)

OBJECTIVE: This program area is concerned mainly with the study and development of harvesting and transportation systems, the anatomical, mechanical, physical and chemical properties of wood and its components, the manufacturing and utilization of wood and related products, effects and control of fungi, insects and other agents on wood, the economics of timber production, harvesting and processing of forest products, the study of institutional managements and legal constraints in timber production, harvesting and manufacturing of forest products, the marketing of forest products, grading and conversion rules and standards, supply, demand and price analysis and forecasting.

APPROACH: Research methods utilized include: Computer simulation of future markets for forest products, future supplies of forest products, and transportation systems; laboratory testing of wood properties; electron microscopy; field investigations of properties of wood products such as fiberboard, press board, glues and resin uses, etc.

PROGRESS: Research is continuing in the following areas: 1) results show that low pH resins were unsatisfactory as adhesives; best results with 10% level of phenol replacement by the precipitated kraft mill lignin 2) to examine role of wood residues and forest biomass as source of energy is initiated 3) a study of the interrelationship of variables which influence the operation of gravity-outhaul skyline system is in progress 4) a study of the dynamic behavior of skyline logging systems is initiated 5) estimates of timber supply based on physical existence of standing timber exaggerate the amount of merchantable wood available. Limitations imposed by harvesting technology and market prices exclude the material from commercial exploitation 6) parallel laminated veneer panels analysis show that Tension-Lam grades produces from 1/8- and 1/10-in. veneer C grade has no apparent effect of width in elasticity, rupture, or tension stress 7) price estimates of 6 primary forest products indicate that price has a short yet delayed influence on quantity demand. Confidence intervals for estimates are wide; long- and short-run elasticities examined; models formulated for the products 8) use of agricultural residues (rice straw, grape vine twig fibers, coconut husk, kraft pulp mill reject fibers) to make corrugated roofing material for low-cost housing continued. Method developed to make material waterproof, durable, stiff, and stronger.

SUPPORTED BY Washington State Government

5.0068,

QUALIFICATION OF BIOMASS FOR USE AND FUELS FOR ENERGY PRODUCTION

R. Smith, University of Washington, School of Forest Resources, *115 Anderson, Seattle, Washington* 98195 (WNZ00048)

OBJECTIVE: Develop a physical-chemical characterization of various hog fuels to be used as reference fuels including the estimation of fuel variability; characterize logging residues and thinnings from a physical-chemical perspective which will help determine the effect which can be spent on their extraction and transportation; develop a physical-chemical characterization for energy fuel-farm grown materials.

APPROACH: A) Characterization of wood fuels by source and species, B) source and species: wood fuel composition will vary depending on its source, C) physical-chemical values developed: partical size distribution, moisture content, heat content, bulk density, proximate analysis, elemental analysis, D) data analysis will be divided into two major categories: 1) within a given fuel type and 2), between fuel type. Eight months each will be required for characterization of hog fuel, logging and thinning residues, and energy fuel-farm material.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Washington

5.0069,

MICROBIAL CHEMICAL AND FUEL PRODUCTION FROM FERMENTATION OF CELLULOSE AND STARCH

J.G. Zeikus, University of Wisconsin, Madison Campus, Agricultural Experiment Station, Dept. of Bacteriology, *116 Agricultural Hall, Madison, Wisconsin* 53706 (WIS02376)

OBJECTIVE: Identify the organisms and experimental conditions that are optimal for the microbial conversion of cellulose and starch to ethanol and acetic acid. New species of thermophilic anaerobic saccharolytic bacteria will be isolated and characterized. Cultural parameters optimal for ethanol and acetate production by Clostridium thermocellum will be determined. The catabolic pathway and its regulation will be studied.

APPROACH: The effect of varying cellulose feed rate, source and supply of exogenous growth factors, temperature, pH, etc. on production (yield and rate) of ethanol and acetate by C. thermocellum will be studied. Enzymatic studies will determine the catabolic pathway in C. thermocellum and seek to understand how metabolic end product formation is regulated. Bacterial enrichment cultures will be initiated to isolate new species of thermophilic, saccharolytic, anaerobic bacteria that metabolize starch, cellulose and glucose, and that are resistant to high levels of ethanol and acetic acid. Species will be taxonomically identified and the yield of ethanol and acetic acid from energy sources determined.

PROGRESS: The metabolic properties of several thermophilic anaerobic bacteria were investigated to examine their potential in fermenting cellulose, starch and wood sugars (esp. xylose) to ethanol and other products. Cellulose metabolism of C. thermocellum was compared with that of Trichoderma viride and was found to be more active in C. thermocellum. Cellulolytic activity in C. thermocellum was studied by examination of cellulase with a novel continuous, spectrophotometric assay method employing dyed cellulose, and by analysis of oligoglucoside transport. The higher cellulolytic activity in C. thermocellum appears to be related to its unique cellulase and mechanism of oligoglucoside transport. A new starch fermenting-ethanol producing bacterium, Thermoanaerobium brockii was isolated and characterized. The catabolic pathways and regulation of ethanol and end product formation were examined in C. thermocellum and T. Brockii. The results obtained indicate that thermophilic anaerobic bacteria have potential utility in bioconversion of cellulose, starch, and wood sugar to fuels and chemicals. This work was supported by Grants 12-76 and 12-140 from the USDA Forest Service.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Wisconsin

6. ENERGY FARMING

6.0001,

POTENTIAL ENERGY EQUIVALENTS OF VEGETATION TYPES IN ARIZONA

P.F. Ffolliott, University of Arizona, School of Agriculture, Renewable Natural Resources Division, *Tucson, Arizona* 85721 (ARZT-0206-4168-220)

OBJECTIVE: This study will derive estimates of the energy equivalents of standing biomass in the vegetation types of Arizona; derive estimates of the energy equivalents of residues associated with current land management practices implemented in these vegetation types; and identify energy equivalents of standing biomass and management residues associated with alterntive land management practices commonly implemented in the respective vegetation types.

APPROACH: Energy equivalents of standing biomass will be determined from extent of area in type, spatial densities of vegetation, rate material growth, specific gravities, and appropriate conversion values. Energy equivalents of management residues will be estimated from knowledge of volumes of residues, specific gravities, and appropriate conversion values. Three levels of biomass energy availabilities will be appropriate conversion values. Three levels of biomass energy availabilities will be generated for each vegetation type: Low, mean (most commonly encounted), and high.

PROGRESS: After preparation of study plan underwhich investigation is to be conducted, initial estimates of extent and volumes of standing biomass in respective vegetation types were completed. In addition, quantifications of base energy equivalents (expressed in terms of Btu's per cubic foot of wood) were derived. Coupling these inputs will furnish preliminary estimates of potential energy equivalents in the vegetation types of Arizona. Similar analytic developments are being formulated to assess potential energy equivalents in vegetative residues often created through implementations of various land management practices. Ultimately, land use management plans will be formulated for the vegetation types under investigation, within the framework of meeting multiresource management objectives.

SUPPORTED BY Arizona State Government

6.0002,

BIOLOGICAL INVESTIGATION OF KELP AS A SOURCE OF ENERGY

W.J. North, California Inst. of Technology, Graduate School, Dept. of Engineering & Applied Sciences, *1201 E. California Blvd., Pasadena, California* 91109 (EY-76-C-03-1275)

SUPPORTED BY U.S. Dept. of Energy

6.0003,

INVESTIGATION OF WOODY BIOMASS SPECIES FOR FUEL PRODUCTION IN WARM CLIMATE NON-AGRICULTURAL LAND IRRIGATED BY BRACKISH OR SALINE WATER

Unknown, Garrett Energy Research & Engineering Co. Inc., *Ojai, California* 93023 (ET-78-C-01-3077)

SUPPORTED BY U.S. Dept. of Energy

6.0004,

HYDROCARBONS AND ENERGY FROM PLANTS

R.M. Sachs, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Environmental Horticulture, *Davis, California* 95616 (CA-D#-EHT-3608-H)

OBJECTIVE: determine the feasibility of and develop preliminary information on the technology for economic production of hydrocarbons and related materials for fuel or chemical feedstocks by means of managed farming of Euphorbias, Asclepias and Eucalyptus.

APPROACH: Periodic evaluation of yields of benzene-acetone extractable hydrocaarbons as well as

total caloric value under two climatic and various cultural conditions. Harvesting and process chemistry methods will also be explored. If yield data and harvesting and processing results are promising, economic analysis of cultural and harvesting costs would be undertaken.

PROGRESS. Euphorbia lathyrus seed were field planted in March; poor germination and poor seedling growth resulted in all test plots. Plantings in Oct. and Nov. were considerably better and will be used for yield vs density evaluations in '79. Plants were treated with 3,4 dichlorophenoxyacetic acid to increase latex (acetone soluble fraction). Eucalyptus grandis plots were harvested twice in '78; yield decline of up to 50% observed in absence of additional N fertilization. Maximum yields of 10 tons dry matter/a obtained with 6-month interval between harvest dates. Caloric value of dried biomass was approx. 8000 BTU/lb. New plants of Eucalyptus are now in field plots for testing in '79. A report on hydrocarbon yields from E. lathyrus will be published in the proceedings of a conference held in Atlanta, GA in 1978.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

6.0005,

STUDIES OF HYDRODYNAMIC INTERACTIONS BETWEEN MARINE PLANTS AND THE WATER AROUND THEM

A.C. Charters, University of California, Santa Barbara Campus, School of Engineering, Dept. of Engineering Research, *Santa Barbara, California* 93106 (ENG76-22720 A01)

This action provides support to complete two phases of research supported under NSF Grant ENG 76-22720. These two phases are: (1) calibration of the vertical low-velocity water tunnel and (2) the use of the tunnel to complete anemometric measurements of the flow field over Macrocystis blade. The general area of research is effects of hydrodynamics on algae growth, in particular kelp growth.

In view of the interest in kelp as a renewable energy source, the information obtained would be useful both in the management of existing kelp forests and in the maricultural establishment of new algal farms.

SUPPORTED BY U.S. National Science Foundation, Div. of Engineering

6.0006,

ECONOMIC IMPACTS OF ENERGY DEVELOPMENT AND USE ON AGRICULTURE AND NATURAL RESOURCES

J.W. Green, Colorado State University, School of Arts Humanities & Social Sciences, Dept. of Economics, *Fort Collins, Colorado* 80523 (NRE-43-309-08-01)

OBJECTIVE: Analyze supply and demand factors that will influence the potential for fuel wood and home heating. Analyze the economic feasibility of energy (biomass) crops, including land and water requirements. impacts on traditional crop production and environmental implications. Assess the economic implications of alternative coal and oil shale development and associated activities on environmental quality and the competition for resources in rural areas.

APPROACH: Asses the economic resource use and environmental implications of public programs to encourage 'energy farms.' Develop regional reports on current land and water use, the economic implications for future resource use, resource competition, and environmental quality resulting from alternative levels of coal and oil shale development, and related activities. Develop an interregional linear program to evaluate conflicting reclamation budgets from available literature, cooperation with other agencies within and without USDA, and limited empirical studies. Budgeting techniques and linear programming will be used to estimate water demand for energy development and to appraise the economic and environmental implications of alternative water supplies.

SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Natural Resource Economics Div.

6.0007,

CAPTURING THE SUN THROUGH BIOCONVERSION - CONFERENCE II

P. Schauffler, Bio Energy Council, *1625 Eye St. N.W., Suite 825A, Washington, District of Columbia* 20006 (PFR77-17117 A02)

This award, a supplement to NSF grant PFR 77-17117 AO1, is for the purpose of providing additional support for the Bio-Energy '80 Conference to be held in Atlanta, Georgia, on April 21-24, 1980. Two additional departments, the Department of Agriculture and the Department of Commerce (National Oceanic and Atmospheric Administration), are contributing supplemental support for the conduct of this conference. The supplement does not change the scope or duration of the project. The conference focuses on biomass sources, conversion processes and products.

SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Problem Focused Research

6.0008,

BIOMASS PRODUCTION AND COMPOSITION OF SUGARCANE

G.J. Gascho, Agricultural Research & Education Center, *P.O. Box 758, Belle Glade, Florida* 33430 (FLA-EV-01862)

OBJECTIVE: Gather sugarcane biomass production and plant composition data for use in energy farming feasibility studies. Specific objectives are: Determine the biomass production, plant composition, nutrient uptake, and leaf area index with time for plants grown at 0.5 and 1.5 m spacings; relate climatic factors such as rainfall, solar radiation, and temperature to biomass and plant composition; and estimate the water requirements of sugarcane grown at the two spacings.

APPROACH: Sugarcane will be planted at 0.5 and 1.5 m row spacings. Monthly harvests will determine biomass for the row spacings. Complete nutrient non-nutrient analyses of tops, stalks and leaves will allow calculations of nutrient uptake and plant composition. Leaf area index and weather data will be regressed against yield parameters. A primary water budget will be estimated by water table, hydraulic conductivity and moisture content measurements.

PROGRESS: Variety CP 65-357 was planted in 0.5-meter and standard 1.5-meter row spacings on muck soil to determine the yields of biomass, total sugars, sucrose and fiber throughout the growing season. Above ground biomass in young cane was much higher for the narrow rows than for the wide rows, due to high stalk counts, which resulted in more complete capture of available sunlight and improved weed control. The advantage of the narrow-row spacing decreased with plant age. Dry biomass in May was more than 300% higher for the 0.5-meter row spacing. In October, the advantage was only 5%. In December, one year after planting, 141 and 41 tonnes per hectare of fresh and dry biomass, respectively, were harvested. Total sugar, sucrose and fiber yields reached 17.0, 15.7, and 18.9 tonnes per hectare, respectively, for mature cane at the 0.5-meter row spacing and 15.4, 13.9, and 17.2 tonnes at the 1.5-meter row spacing. The application of Polaris six weeks prior to the final harvest significantly increased yields of both total sugars and sucrose. Date from ratoon cane, as well as from a row spacing experiment on sand and a sweet sorghum experiment are being collected and summarized for next year's report.

SUPPORTED BY Florida State Government

6.0009,

BIOMASS PRODUCTION AND COMPOSITION OF SUGARCANE

S.F. Shih, State University System of Florida, University of Florida, Agricultural Research & Education Center, *Belle Glade, Florida* 33430 (EV-1862)

Sugarcane growth and biomass production are superior to other crops in subtropical areas such as south Florida. Presently 125,000 ha of cane are grown and the value of sugar and molasses produced was 340 million dollars in 1975-76. Millions of acres of sand soils surrounding the organic soils in south Florida are also potential areas for producing sugarcane for biomass. Possibly, alternative use of the total sugarcane biomass will be feasible in the near future due to energy shortages and/or high fuel prices. Technology exists for conversion of the biomass to fuels such as alcohol or ammonia. Ammonia could be used in the south Florida area for fertilizers or cattle feed. The overall objective of the study is to gather sugarcane biomass production and plant composition data for use in energy farming feasibility studies. The specific objectives of the proposal are: (1) to determine the biomass production, plant composition, nutrient uptake, and leaf area index with time for plants grown at 0.5, 1.0 and 1.5 m spacings on sand and 0.5 and 1.5 on organic soil; (2) to relate climatic factors such as rainfall, solar radiation, and temperature to biomass and plant composition; (3) to estimate the water requirements of sugarcane grown as affected by row spacing; and (4) to investigate subsidence rate of organic soil relative to row spacing.

SUPPORTED BY U.S. Dept. of Energy

6.0010,

SUGAR CANE GROWTH FOR USE AS AN ENERGY CROP

Unknown, State University System of Florida, University of Florida, Agricultural Research & Education Center, *Belle Glade, Florida* 33430 (ET-78-G-05-5890)

SUPPORTED BY U.S. Dept. of Energy

6.0011,

BIOMASS PRODUCTION AND COMPOSITION OF SUGAR CANE

J.W. Mishoe, State University System of Florida, University of Florida, School of Agriculture, Dept. of Agricultural Engineering, *Gainesville, Florida* 32601 (FLA-AG-01862)

OBJECTIVES: The overall objective is to gather sugar cane biomass production and plant composition data for use in energy farming feasibility studies. Specific objectives are: Determine the biomass production plant composition, nutrient uptake, and leaf area index with time for plants grown at 0.5 and 1.5 m spacings; relate climatic factors such as rainfall, solar radiation, and temperature to biomass and plant composition; and estimate the water requirements of sugar cane grown at the two spacings.

APPROACH: Sugar cane will be planted at 0.5 and 1.5 m row spacings. Monthly harvest will determine biomass for the row spacings. Complete nutrient and non-nutrient analysis of tops, stalks and leaves will allow calculations of nutrient uptake and plant composition. Leaf area index and weather data will be regressed against yield parameters. A primary water budget will be estimated by water table, hydraulic conductivity and moisture content measurements. A sugar cane growth model will be developed and need to schedule harvest to maximize yields.

SUPPORTED BY Florida State Government

6.0012,

ENERGY AND CHEMICALS FROM WOODY SPECIES IN FLORIDA

W.H. Smith, State University System of Florida, University of Florida, School of Forest Resources & Conservation, *Gainesville, Florida* 32601 (FLA-FY-01924)

OBJECTIVE: Proposed work is aimed at assessing the potential for sustained production of biomass by species of Pinus, Eucalyptus, and Melaleuca in Florida. Land availability and productivity will be assessed to focus field experiments on the most suitable sites.

APPROACH: Field trials will be designed to evaluate effects of site preparation, fertilization, and cropping components of cultural treatments. Site effects of biomass-farming on water use and nutrient conservation will be evaluated. Results will also include evaluation or rotation age and energy input/output efficiencies.

PROGRESS:

SUPPORTED BY Florida State Government

6.0013,

HARVESTING AND PLANTING SYSTEMS FOR MECHANIZING SUGARCANE PRODUCTION FOR SUGAR OR BIOMASS

J.E. Clayton, U.S. Dept. of Agriculture, Agricultural Research, Sugarcane Harvest Res, *P.O. Box 758, Belle Glade, Florida* 33430 (7614-20190-003)

OBJECTIVE: Develop engineering components and systems for improving the mechanical harvesting and planting of sugarcane. Develop equipment for maximizing production and reducing harvester costs for sugarcane grown as biomass.

APPROACH: Design and evaluate harvester mechanisms for adjusting cutter height and removing loose trash as stalks are cut at ground level. Desigh improved harvester components for topping, feeding, chopping, cleaning, and conveying surgacane with 10% less energy than prototype harvesters now in use. Develop planting systems and harvester pickup mechanisms for narrow-row spacings likely to be used when growing sugarcane for biomass. Redesign and cushion harvester components to minimize damage and improve the cleaning of surgarcane harvested for seed. Improve mechanical planter components to reduce damage to sugarcane seed and refine sensing mechanisms for detecting skips.

PROGRESS:
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Florida - Antilles Area

6.0014,
LAND MANAGEMENT ALTERNATIVES FOR SOUTH FLORIDA

T.F. Geary, U.S. Dept. of Agriculture, Forest Service, Southeastern Forest Experiment Station, *Lehigh Acres, Florida* 33936 (SE-1113)

OBJECTIVE: Develop technology for the commercial culture of eucalypts in Florida.

APPROACH: Development of a procedure to single seed nursery containers will be attempted to reduce nursery costs and improve mechanization. Success will depend on finding techniques to clean and pellet eucalypt seeds. Seeds for plantations will come from tree strains to be bred specially for south Florida. Methods must be developed to vegetatively propagate seed trees of the superior strains, and for improving seed production and harvesting. Growth of different strains on several soil groups following varying site preparation techniques will be measured to determine the most productive combinations. Increase productivity, new fertilizer prescriptions will be tested, as well as new methods to control weeds on oldfields.

PROGRESS: Project scientists helped design a new nursery container for growing eucalpyptus and other hardwood seedlings that need wide growing space for good stem caliper. The new container holds 77 seedlings at a spacing of 25 seedlings per ft . The cone-shaped root plugs are 5 inches long and 1.4 inches wide at top and can be machine planted. A seed orchard was planted to test a unique pollination cluster design for producing hybrid eucalyptus seed. Hybrids grow faster, are more cold hardy, and coppice better than parents. Work continued on measuring yields of eucalyptus plantations. Volume yield of merchantable pulpwood trees of E. grandis was equal at spacings from 4x8 to 16x8 ft, but total volume was 1.7 times greater at the closer spacings. Biomass energy plantations should probably be planted at closer spacing than pulpwood plantations. The mai of E. robusta in a pilot plantation was 2.6 cords/ac/yr at age 8.25 years, an increase over the year before, and suggesting that rotation length should be at least 9 years or more.

SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Southeastern Forest Experiment Station

6.0015,
BIOMASS PRODUCTION OF SHORT ROTATION COPPICE FORESTRY

K.L. Steinbeck, University of Georgia, School of Forest Resources, *Athens, Georgia* 30601 (EG-77-S-09-1015)

SUPPORTED BY U.S. Dept. of Energy

6.0016,
EUCALYPTUS PLANTATION DEVELOPMENT FOR ENERGY PRODUCTION

Unknown, C. Brewer & Co. Ltd., *P.O. Box 1826, Honolulu, Hawaii* 96805 (ET-78-F-03-2159)

SUPPORTED BY U.S. Dept. of Energy

6.0017,
GENETICS AND AGRISILVICULTURAL STUDIES OF TROPICAL WOODY LEGUMES

J.L. Brewbaker, University of Hawaii System, Manoa Campus, Agricultural Experiment Station, Dept. of Horticulture, *Gilmore Hall, Room 102, Honolulu, Hawaii* 96822 (HAW00803)

OBJECTIVE: Identify Leucaena strains with high fuel and wood productivity. Breed Leucaenas with high forage and N-fertilizer yields and low mimosine contents. Identify Acacia cultivars with superior agrisilvicultural properties. Assemble and evaluate germplasm of Mimosaceous legumes with promise as fuel or N sources in tropics.

APPROACH: Yield trials with variety, density, management, and environment as variables. Breeding and genetic studies of leucaena species, varieties, and their progenies. Yield trials of Acacia koa and other acacias ssitable for forest product and recreational use in Hawaii. Seed and cultivar collection, introduction, and evaluation in Hawaii for fuel and forage or nitrogen productivity.

PROGRESS: A germplasm bank was established of seeds of the Hawaiian Acacia species A. koa and A Koia. A reputed thrid species, A. kauaiensis, could not be verified. Collections were made from all major islands and all major natural populations were designated. The breeding system of A. koa was determined to be primarily by cross-pollination, due to a dichogamy of several days between male and female parts of the same flower, and a high synchrony of the floweres on a tree. There was no self-incompatibility. Seed production was reduced significantly by rains and low insect populations at flowering time in the spring and by seed weevils. Koa was shown to be of two major bole types that appear to be distinct genetically, the predominant form a low-branching wide-crowned tree. Only on the island of Hawaii were there large populations of an erect, tall form that branched sparsely. Genetic variations in leaf and pod type and in peroxidase isoenzymes were described, and studies conducted of seed germination, and of nodulation and soil management for seedling establishment.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Hawaii

6.0018,
ESTABLISHMENT OF AN ENVIRONMENTAL AND RESOURCE ASSESSMENT PROGRAM FOR THE FUELS FROM BIOMASS PROGRAM

R.G. Matlock, U.S. Dept. of Energy, Argonne National Lab., *9700 S. Cass Ave., Argonne, Illinois* 60439 (AD-02-01)

This program will provide technical support to the Environmental and Resource Assessment Branch, Division of Solar Energy, to develop an environmental and resource assessment program for the fuels from biomass program. Technical support will be provided by five ANL staff, one of whom will be headquartered at the ANL Washington office and directly available to the Branch Chief, and a ten person review panel. Five tasks are to be accomplished: (a) a review and assessment of the EDP, ERAP, preliminary ERA project list, technology development status and ETRM information; (b) establish a priority ranking of the environmental and resource assessment tasks; (c) review and revise the priority ranking; (d) develop a procurement document for the environmental and resource assessment program; and (e) prepare a project plan.

SUPPORTED BY U.S. Dept. of Energy

6.0019,
THE UTILIZATION OF TWO-YEAR SHORT-ROTATION DECIDUOUS BIOMASS FOR ENERGY, PARTICLEBOARD AND CHEMICALS

P. Chow, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Forestry, *Urbana, Illinois* 61801 (ILLU-55-0304)

OBJECTIVE: Develop efficient ways to use solar renewable woody biomass grown under intensive silvicultural techniques as substitutes for non-renewable fossil fuels through gasification and combustion. Evaluate the feasability of converting high-yield plantation-grown wood to paper and particleboard so as to stretch future wood supplies. Determine the chemical composition (acidicity, extractive content, cellulose, lignin, and pentosan content) and physical properties of seven biomass plantation species. Determine the potential exonomic value of various products made from high-yield woody biomass.

APPROACH: A 7 x 2 x 2 factorial design involving 7 species (autumn olive, black alder, black locust, E cottonwood, royal paulownia, silver maple, and sycamore),2 sites (bottomland and upland), and 2 regeneration techniques (seedling and coppicing) will find the effects of species, site, and regeneration techniques on the fuel values, paper and board properties, and chemicals made from 2-year old juvenile wood. The experiment is divided into five phases.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Illinois

6.0020,
SOLAR ENERGY CONVERSION THROUGH WOODY BIOMASS PRODUCTION

G.L. Rolfe, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Forestry, *Urbana, Illinois* 61801 (ILLU-55-0342)

OBJECTIVE: Develop a net energy balance for energy plantations. Determine relationships between four woody species and biomass yield. Determine the optimum spacing and cutting cycle for these species. Determine the nutrient requirements and best method of supplying these nutrients for sustained biomass yield. Develop site selection criteria in order to determine those marginal lands best suited for energy production.

APPROACH: A series of field test plots will be established on a range of sites in central and southern Illinois to evaluate the potential of various species for maximum biomass production for energy conversion. Nutrient requirements will also be determined through tissue and soil analysis during the growth period. Energy yields will be measured and a net energy balance developed.

PROGRESS: Preliminary woody biomass production plots were established during the Spring of 1978 to evaluate stand establishment requirements on marginal sites in Southern Illinois. Plots included cottonwood, sycamore, autumn olive and silver maple at 9-inch and 12-inch spacings with a range of plot sizes up to .3 ha. From these preliminary studies it was determined that intensive site cultivation followed by irrigation and herbicide application are necessary for establishment of these intensive woody production plots. Production data from these preliminary plots will be collected at the end of the second growing season. Herbicide trials indicate sinbar at 1-2 kg/ha to be the most effective herbicide on sycamore plots with minimal damage to the woody plants and karmex at 1-2 kg/ha to be the most effective on autumn olive plots. Studies are continuing with main plot planting scheduled for Spring 1979.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Illinois

6.0021,
SAFETY AND PERFORMANCE OF TRACTORS AND MACHINERY

J.B. Liljedahl, Purdue University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Executive Bldg., West Lalayette, Indiana* 47907 (IND046018)

OBJECTIVE: Study methods of reducing accidents; study methods of reducing noise from tractors and machinery; study methods of improving tractor control; predict dynamic behavior of tractors, and improve traction on tractors.

APPROACH: Use surveys, experimental studies, use of tractor ride simulator, develop and test mathematical models, and use simulitude and the agri engineering soil bin to test methods of improving traction.

PROGRESS: Began in July a study of the performance of machines for harvesting, transporting and storage of crop residues as energy crops. Helped prepare an extensive report on Bio-Mass for the U.S. Office of Technical Assessment with the Purdue Department of Agricultural Economics. Report will be available in April 1979. Completed in November a study to maximize traction of tractors on sandy soils. The work is the Ph. D. research of a student from North Africa. The thesis should be complete in March 1979. Began a study to maximize traction of tractors on flooded rice soils. This work is the Ph. D. research of a student from Nigeria. The objective of the study is to find an optimum design for set of wheel extensions.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Indiana

6.0022,
HARDWOOD SPECIES AND CULTURAL PRACTICES NEEDED FOR RAPID FIBER PRODUCTION

W.A. Geyer, Kansas State University, Agricultural Experiment Station, McIntire Stennis Program, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00770)

OBJECTIVE: Development of streamside sites for wood fiber production utilizing rapid growing hardwoods and intensive silvicultural practices: (1) Selection of tree species for rapid growth rate, tree form, and wood quality. (2) Determine resprouting ability. (3) Develop optimum spacing and cultural techniques.

APPROACH: Native and non-native species, cottonwood varieties, and hybrid-poplars will be secured; stressing types adapted to plains conditions from superior trees. Initial collections and additions will be outplanted at basic spacings of 2 x 2, 3 x 3, and 4 x 4 feet to supply early evaluations of factors listed under objective 1. Separate plantings will be made to determine sprouting ability and quality following continuous annual cuts. Desirable selections from initial plantings will be tested at spacings convenient for mechanical handling. Weed control, fertilizer applications, and irrigation will be investigated.

PROGRESS: This project has been revised with the following three objectives being investigated: Continue measuring growth and yield on established short rotation forestry (SRF) plots. Investigate cultural practices necessary for SRF. Conduct preliminary investigation for nutrient status of SRF plots. Six-year information was collected this December and data is presently being evaluated. The following data was compiled for the first 4 years of growth (2 seedling, 2 coppice) on the SFR plots. Over a period of years 7

tree species were planted at 3 different spacings -- 1x4, 2x4, and 4x4 feet. On silty soils, 2 year seedling field weights were 9.3, 9.0 and 7.9 tons/acre for the closest to the widest spacing. A greater delineation between spacing was found on the sandy soils, being 7.0, 5.8 and 4.6 tons/acre. Coppice growth the following two years was 50% greater at all spacing on the loamy sites and 30% greater on the sandy site. The most promising species appear to be cottonwood, silver maple and E. black alder. Boxelder, sycamore and sandbar willow have less potential on the sites tested. The relative heating value of dry wood (BTU/ft 3) indicate all species tested were 10-30% higher than the base line species -- cottonwood.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Kansas

6.0023,
OPTIMIZATION TECHNIQUES FOR AGRICULTURAL PROBLEMS
L.T. Fan, Kansas State University, School of Engineering, Dept. of Chemical Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN00737)
OBJECTIVE: Demonstrate applicability of methods of system analysis and synthesis to a variety of agricultural problems including fertilizer production and application, food production and consumption, biomass energy resources conversion and utilization, and water utilization and conservation. The ultimate goal of analysis and synthesis of any system is to optimize its performance.
APPROACH: Multiobjective optimization techniques will be used to simultaneously minimize or maximize two or more objective functions such as production cost and energy efficiency. Experimental optimization techniques will also be used in the optimal design of equipment and apparatus for implementing the predicted optimal policies.
PROGRESS: Single-Cell Protein Production by Photosynthetic Bacteria. Photosynthesis is one of the basic biochemical processes, in which plants, algae, and specialized populations of bacteria convert the energy from sunlight or solar energy into chemical energy for cellular biosynthesis. Man has used this natural process of harnessing solar energy in the development of algal cultivation systems for secondary waste treatment and for the production of human foods, livestock feeds, and fertilizers. Optimal designs of processes for mass-culturing photosynthetic bacteria have been investigated. Bio-Plastics and Single-Cell Protein from Starch and Agricultural Wastes. It is possible to produce not only single-cell protein (SCP) but also biologically-based polymers (including plastics, resins and fibers) by fungi from nonpetrochemical starting materials. Renewable resources serving as substrates for the fermentation-based process include starch, waste starches and other sources of crude sugars that result from enzymatic or acid-hydrolysis of municipal refuse, wood, corn cobs, agricultural by-products, and other cellulosic wates. Experimental and theoretical optimization of this process is under investigation. Other systems and processes being investigated are membrane-moderated controlled release, enzymatic hydrolysis of cellulosic materials, and processing of Jerusalem Artichoke.
SUPPORTED BY Kansas State Government

6.0024,
MANAGEMENT OF AMERICAN SYCAMORE (PLATANUS OCCIDENTALIS L.) ON SHORT COPPICE ROTATIONS
R.F. Wittwer, University of Kentucky, Agricultural Experiment Station, Dept. of Forestry, *Limestone & Euclid, Lexington, Kentucky* 40506 (KY00619)
OBJECTIVE: Evaluate influence of spacing, fertility, and rotation age on production of above-ground biomass on different sites. Determine the uptake, distribution and possible removals of nutrient elements in the above-ground biomass.
APPROACH: Total above-ground biomass production of coppice growth on young, closely-spaced Platanus occidentalis L. plantations established on different sites at various spacings, subjected to various fertilizer treatments and harvested at various rotation ages will be measured. Nutrient uptake and distribution in the biomass will be determined. Results will be analyzed to develop systems for maximizing production of cellulose.
PROGRESS: Four-year-old coppice plots of American sycamore (Platanus occidentalis) were harvested to determine total above-ground biomass yields. Silvicultural treatments evaluated were initial spacing (0.3 x 0.9m, 0.9 x 0.9m, 1.8 x 0.9m), fertilization (none, 169 Kg/ha elemental N applied annually, and the N treatment plus 112 Kg/ha elemental P applied annually), and site (bottomland and terrace). Yields tended to increase with increased spacing. The N and N plus P fertilizer treatments had a similar effect on yields and approximately doubled biomass compared with unfertilized controls. Yields were approximately 50% higher on the terrace site. Highest yields were achieved on the wider-spaced, fertilized plots on the terrace and averaged approximately 107 mt/ha on a green-weight basis.
SUPPORTED BY Kentucky State Government

6.0025,
SUGARCANE AND SWEET SORGHUM AS A RENEWABLE BIOMASS ENERGY RESOURCE
B.J. Cochran, Louisiana State University, Agricultural & Mechanical College, Agricultural Experiment Station, Dept. of Agricultural Engineering, *University Station, Baton Rouge, Louisiana* 70803 (LAB02011)
OBJECTIVE: Determine the effects of spacing and row profiles on the biomass yield of plant and ratoon sugar cane and sweet sorghum. Study the yield components and other factors affecting yields of plant and ratoon sugar cane during various stages of plant growth. Evaluate methods of mechanical harvesting sugar cane and sweet sorghum grown from the planting and production treatments of objective 1. Study commercial mechanical systems available for harvesting maximum sugar cane biomass in the sugar cane production areas of the United States.
APPROACH: The research will be conducted at the St. Gabriel station. Studies involving sugarcane will be made to determine effect of type and width of planting farrows on growth, yield, and harvestability if sugarcane from plant cane of ratoon crops. Plant population will be varied by conventional planting methods and single drill and multiple drill with different spacing and planting rates. A similar plan will be used with sweet sorghum. Planting methods, equipment for covering, harvesting means will be evaluated. Biomass data will be collected.
SUPPORTED BY Louisiana State Government

6.0026,
HYBRIDIZATION SACCHARUM SPECIES AND RELATED GENERA
P.H. Dunckelman, U.S. Dept. of Agriculture, Agricultural Research, Sugarcane Field Lab., *Box 470, Houma, Louisiana* 70360 (7412-20090-007)
OBJECTIVE: Enlarge the genetic base in Saccharum by incorporating into commercial breeding lines new germplasm having characters for high cane tonnage, up to 75 tons/ha using conventional cultural practices and up to 185 tons/ha for biomass and narrow row plantings; stubbling ability for up to 5 to 6 years; mosaic and ratoon stunting disease resistance (near immunity); and freeze resistance to -6 C.
APPROACH: Hybridize selected germplasm from the World Collection of Sugarcane and related grasses. Backcross or intercross selected clones. Select progeny for desired characters. Synchronize and promote flowering of divergent species in order to make crosses by control of temperature, photoperiod, and other environmental/cultural conditions.
PROGRESS: One hundred and fourteen intergeneric and biparental sugarcane crosses were made between commercial breeding lines and selections from new breeding lines including Saccharum spontaneum, S. robustum, Sclerostachya, Ripidium, and Erianthus. Over 440,000 viable seeds were produced. BC(2) and BC(3) clones from S. spontaneum US 56-15-8 were included in agronomic trials. Two new S. spontaneum lines (SES 84/58 and SES 602) were started for selection of sugarcane varieties for biomass production.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mississippi Valley Area

6.0027,
SUGARCANE QUALITY AS AFFECTED BY ENVIRONMENT, VARIETIES, OR MANAGERIAL PRACTICES
J.E. Irvine, U.S. Dept. of Agriculture, Agricultural Research, Sugarcane Field Lab., *Box 470, Houma, Louisiana* 70360 (7412-20090-009)
OBJECTIVE: Determine effect of environment, variety, and farm practices on mineral and major organic constituents, energy content, and extraneous matter.
APPROACH: Measure the major inorganic and organic constituents as affected by season, freezing, variety, sprays, and other factors. Determine energy content of biomass sugarcane under different cultural regimes and the effect of extraneous matter on constituents and energy content.
PROGRESS:
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mississippi Valley Area

6.0028,
FEASIBILITY OF REED BIOMASS ENERGY CONVERSION
J. Drifmeyer, Bio Test System Inc., *Edgewood, Maryland* 21040
SUPPORTED BY U.S. Dept. of Energy

6.0029,
CULTIVATION OF MACROSCOPIC ALGAE FOR ENERGY CONVERSION, HYDROCOLLIO PRODUCTION, AND ADVANCED WASTEWATER TREATMENT
J.H. Ryther, Woods Hole Oceanographic Institution, *Main St., Woods Hole, Massachusetts* 02543 (EY-76-S-02-2948)
SUPPORTED BY U.S. Dept. of Energy

6.0030,
TREE SPECIES FOR BIOMASS PRODUCTION IN NORTHERN MICHIGAN
J.W. Hanover, Michigan State University, School of Agriculture & Natural Resources, Dept. of Forestry, *Soil Science Bldg., East Lansing, Michigan* 48823 (ET-78-G-01-3078)
SUPPORTED BY U.S. Dept. of Energy

6.0031,
CLASSIFICATION, PROPERTIES AND UTILIZATION OF MINNESOTA ORGANIC SOILS
R.S. Farnham, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Soil Science, *St. Paul, Minnesota* 55101 (MIN-25-017)
OBJECTIVE: Characterize the properties of organic soils or as aid to classify and survey them and evaluate their potential for agriculture, as an energy source and for waste treatment.
APPROACH: Labortory and field studies including peat surveys and studies to aid development of organic soils for crop production, energy and waste treatment, hydrologic and water quality studies of peatland environments to be made.
PROGRESS: The Anoka peatland project was continued and additional water quality and soil fertility studies were added. Studies on biomass crops for energy grown on organic soils were started under a grant from U.S. Dept. of Energy. Final report of a Minn. Dept. of Natural Resources sponsored survey of 'Agricultural Uses of Minn. Peatlands' was completed. Assisted U.S. Forest Service, S.C.S., U.S. Geol. Survey and U.S. Bureau of Mines in classification and survey of organic soils. Basic studies on peats concerned with chemical, physical and energy analyses were continued. Research was conducted for D.N.R. on agricultural reclamation of mined peat lands. In August I attended two Int'l Peat Society symposia-one in Finland and one in Norway. Also visited research institutes in Sweden concerned with peat and plant biomass grown on peat for energy. Attended two biomass conferences in the U.S. and a wetlands conference in Fla. Was chairman of the U.S. National Comm. of the Int. Peat Society and have been working on plans for Congress in Minn. in 1980.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Minnesota

6.0032,
CROP PRODUCTION POTENTIAL FOR FOOD AND ENERGY ON MINNESOTA PEATLANDS
R.S. Farnham, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Soil Science, *St. Paul, Minnesota* 55101 (MIN-25-023)
OBJECTIVE: Study the potential of new crops and varieties and their adaptability to Minnesota growing conditions on organic soil areas including fertilizer studies, disease and insect control, and other management studies. Study the potential of Minnesota peatlands for the production for peat and of biomass corps grown on peat as an alternate energy source. Use research information to recommend the type and location of peatlands for agricultural development and as an energy source.
APPROACH: Field and greenhouse studies will be instituted in St. Paul and at out-state locations some on farmer's fields, evaluate the potential of selected Minnesota peats for crop production, including bio-

mass crops, under carefully controlled invironmental conditions. Emphasis will be on evaluating promising new crops and varieties such as horticultural crops, wild rice, woody shrubs, sedges, and grasses. Management practices will include fertilizer trials, disease and insect controls, and weed control. Organic soils will be collected statewide for analysis and for greenhouse screening.
SUPPORTED BY Minnesota State Government

6.0033,
BREEDING MAINTAINING AND INCREASING PRODUCTIVITY OF SWEET SORGHUM FOR SIRUP, SUGAR AND ENERGY

K.C. Freeman, U.S. Dept. of Agriculture, Agricultural Research, *Rte. 10 Box 152, Meridian, Mississippi* 39301 (7403-20090-005)
OBJECTIVE: Develop varieties of sweet sorghum with improved yield, juice quality, sirup quality, sugar quality, biomass yield, fiber quality, disease resistance, and agronomic characteristics. Determine the effects of various cultural practices upon the yield and quality of sweet sorghum varieties for sirup, sugar and renewable energy source.
APPROACH: Conduct comprehensive breeding and cultural studies program including evaluation of germ plasm. Testing selections and exotic importations and regional and interregional evaluation of evaluation of varieties. Utilize information on inheritance of disease resistance and qualitative and quantitative traits, as Brix, sucrose, fiber, sirup, sugar, and alcohol per ton of stalks in the sweet sorghum breeding program. Utilize aspects of the culture of sweet sorghum for improved handling, processing, and management practices.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mississippi Valley Area

6.0034,
SWEET SORGHUM GERM PLASM MAINTENANCE

K.C. Freeman, U.S. Dept. of Agriculture, Agricultural Research, *Rte. 10 Box 152, Meridian, Mississippi* 39301 (7403-20090-007)
OBJECTIVE: Culture and maintain World Sweet Sorghum Germ Plasms Collection and provide germ plasm source seed to other researchers and germ plasm centers. Evaluate accessions for potential use as parent crosses to produce sirup, sugar and energy. Classify accessions.
APPROACH: Maintain storage of exotic lines under optimum controlled temperature and humidity conditions. Conduct periodic germination tests of stored seed to project the need for reproducing lines to maintain seed viability. Make field and greenhouse plantings of exotic lines ad needed to restore and maintain viable seed sources. Evaluate, collect, and computerize descriptor data of field planted accessions. Evaluate data to select potential parent lines for incorporation of desirable characteristics into breeding program.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Mississippi Valley Area

6.0035,
ABOVEGROUND BIOMASS YIELDS FOR SHORT-ROTATION PONDEROSA PINE STANDS IN WESTERN MONTANA

S.D. Tesch, University of Montana, School of Forestry, McIntire Stennis Program, *Missoula, Montana* 59801 (MONZ07806)
OBJECTIVE: Determine the aboveground biomass production potential for ponderosa pine on three western Montana soil types. Assess how much within-soil type variability in biomass production can be explained by the use of habitat typing. Test significance of site index for predicting biomass production. Develop multiple regression models for prediction.
APPROACH: Sample stands to obtain tree and site data. Analyze data and develop regression models.
PROGRESS: Five hundred and thirty-nine plots have been sampled on three soil types theoretically representing poor, good, and very good site conditions. We successfully found three habitat types which were ubiquitous to all three soil types and sampled plots ranging in age from 10-80 years, for each habitat type, within each of the soil types. The approximately 60 samples in each of the nine subgroups also contain a range of stand densities. Laboratory analysis of increment cores to determine target tree ages and growth rates is nearly complete. Efforts will then be directed at getting the data entered into the computer with data analysis and model development beginning thereafter.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Montana

6.0036,
DEVELOPMENT OF TECHNIQUES TO MEASURE AND PREDICT BIOMASS OF SINGLELEAF PINYON AND UTAH JUNIPER

E.L. Miller, University of Nevada, Reno Campus, Agricultural Experiment Station, Dept. of Renewable Natural Resources, *Reno, Nevada* 89507 (NEV00664)
OBJECTIVE: Develop prediction equations which use measureable, independent tree variables to estimate above-ground biomass as related to resource potentials and quantity of fuel. Obtain data for analysis of growth relations and site quality of pinyon-juniper stands in Nevada.
APPROACH: The entire above-stump biomass of randomly selected trees will be obtained for deadwood, green material larger than 3-inches diameter, and green material smaller than 3-inches. The proportions of foliage, twigs less than 1/4 in., branches 1/4-to 1-in., and branches 1-to 3-in. diameter will be determined by sampling. Representative disks and samples will be taken to the laboratory for oven-drying. Using various tree and site parameters, prediction equations will be developed for estimating resource potentials and quantity of fuel.
PROGRESS: Field work has been completed at 19 study plots across Nevada. Aboveground biomass measurements have been obtained for 76 pinyon and 33 juniper trees. Regression analysts techniques have been utilized to select those tree variables which best estimate and predict total aboveground biomass and also biomass of the various size classes, such as cordwood and slash. Results indicate that log transformations and using two or three variables provide the best prediction equations. For pinyon, tree height and diameter at stump height are the most significant variables while for juniper, average crown diameter and dbh are the most significant. Biomass tables have been constructed for on the ground and aerial cruising in the p-j type. The final report will be published as a Research Paper - Intermountain Forest and Range Experiment Station.
SUPPORTED BY Nevada State Government

6.0037,
EVALUATION OF TREE SPECIES FOR ENVIRONMENTAL AMELIORATION AND ENERGY PRODUCTION

E.L. Miller, University of Nevada, Reno Campus, Agricultural Experiment Station, Dept. of Renewable Natural Resources, *Reno, Nevada* 89507 (NEV00671)
OBJECTIVE: Develop recommendations for using tree species in the production of energy and to modify environmental conditions.
APPROACH: Tree plantings with a reasonable known history will be evaluated as to performance and cultural requirements; tree sub-stations which represent distinctly different climatic conditions will be selected and a species testing program initiated. Replicated plots will be used at each location to determine tree performance in regard to survival, growth, cultural requirements, and pest resistance.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Nevada

6.0038,
WOOD PRODUCTIVITY AND SOCIAL OPPORTUNITY OF TOWN FORESTS IN NEW ENGLAND

J.E. Carroll, University System of New Hampshire, University of New Hampshire, Inst. of Natural & Environmental Resources, McIntire Stennis Program, *Pettee Hall, Durham, New Hampshire* 03824 (NH00019-M)
OBJECTIVE: Determine the characteristic and stage of management of several town forests and compare the present output of goods and services to potentials under alternative management strategies. Develop and evaluate models for the administration of town forests to insure continuity in management.
APPROACH: Select four (or more) towns in southern, central, and northern New Hampshire as case studies. In these towns, we will evaluate the timber, educational, and recreational values in detail under alternative management strategies. From these results, we will develop a model for application to other town forests in New England. Develop model administrative systems based on the present structure of town and state governments in the New England region and on an adaptation of Ontario's administrative system for locally owned forest areas similar to town forests. In this adaptation, attention will be given to opportunities for grouping town-owned tracts into single administrative units such as by drainage basin or political subdivision.
PROGRESS: An analysis of present and potential timber values was made on three town forests selected in New Hampshire. As part of the analysis, a computer inventory program called INVENT was written. INVENT is widely used by landowners in New Hampshire. The analysis indicates that potentially the sale of timber can cover the cost of forest management activities to improve the timber and cover recreational activities such as hiking, cross country skiing, and picnicking. On some forests with well-stocked stands of merchantable size, these costs can presently be covered by sale of timber.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, New Hampshire

6.0039,
ASSESSMENT OF RESOURCE-LIMITED INPUTS TO FOOD PROTEIN PRODUCTION SYSTEMS

D. Pimentel, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Entomology, *Ithaca, New York* 14850 (NYC-139362)
OBJECTIVE: Assess current energy, labor, and land resource inputs in animal and plant(cereal, legume, and vegetable) protein production in the United States; and assess the potential for energy and cropland resource conservation if a shift were made to 'grass-fed' animal protein production in the United States.
APPROACH: Direct and indirect energy, labor, and land (by class) inputs for several crops and livestock systems in different regions of the nation will be analyzed to estimate current resource uses nationwide for these systems. Three principal subsystems of the food production system will be analyzed: Cropland; grassland and cropland combined with intensive livestock production; and grassland combined with extensive livestock production. Simple models will be used to provide first-order approximations of energy, land, and labor resource inputs for the current protein production system and the alternate system. Aggregate functions describing the 'physical relationships', between energy, land, and labor resource inputs and the qualtiy of food protein produced will be developed for each subsystem.
PROGRESS: Solar energy conversion by agriculture and forestry is an important factor in U.S. energy policy, and the total harvested annually amounts to 5.8 multiplied by 10 1 5 kcal of net energy. This is about 32% of the annual U.S. fossil energy consumption (18 multiplied by 10 1 5 kcal). The utilization, however, of other readily available biomass sources like manure, other wastes, and some energy farming for energy conversion is much more limited than agriculture and forestry. The potential annual yield of energy from these other biomass sources (372 Mt) is estimated to be about 0.34 multiplied by 10 1 5 kal of net energy. This represents only 1.9% of current fossil energy consumption, but this potential should be developed.
SUPPORTED BY New York State Government

6.0040,
PRODUCTION AND SELECTION OF DUCKWEED (LEMNACEAE) STRAINS FOR THE REMOVAL OF WATER POLLUTANTS RESULTING FROM ENERGY PRODUCTION (ABBREV)

W.S. Hillman, U.S. Dept. of Energy, Brookhaven National Lab., Dept. of Biology, *Upton, New York* 11973 (EY-76-C-02-0016)
The production and use of energy is inextricably related to environmental water quality. Energy-related pollutants include heavy metals and acidic oxides from fuel combustion brought down in precipitation; runoff from mining; water from boilers and heat exchangers; and runoff from agricultural land and feed lots operated at high energy expense. Thus the treatment of water to remove such substances and recover those that are useful is crucial to energy management. The advantages of using biological components in such treatment include the possible use of the organisms involved as either biomass energy sources--e.g., in methane fermentation--or as animal feeds. The Lemnaceae--duckweeds--have the most rapid sustainable vegetative growth rates known among higher plants; their floating habit and small but macroscopic size make their separation from water far simpler than that of other organisms used or proposed for similar purposes. Preliminary work elsewhere with wild material is encouraging with regard both to the removal of pollutants and

subsequent use of the plants. The goal of this project is thus to develop strains with high capacities for the removal or destruction of specific pollutants and with other properties desirable in integrated water-management systems.
SUPPORTED BY U.S. Dept. of Energy, Office of Health & Environmental Research

6.0041,

SPECIES SELECTION AND SIVICULTURAL SYSTEMS FOR PRODUCING FUELS FROM WOODY BIOMASS IN THE SOUTHEASTERN U.S.

Unknown, University of North Carolina, North Carolina State University, Graduate School, *Raleigh, North Carolina* 27607 (ET-78-G-01-3038)
SUPPORTED BY U.S. Dept. of Energy

6.0042,

ENERGY POLICY, BIOMASS, AND AGRICULTURE - AN ECONOMIC ANALYSIS

N. Rask, Ohio State University, Columbus Campus, School of Agriculture & Home Economics, Dept. of Argicultural Economics & Rural Sociology, *190 N. Oval Dr., Columbus, Ohio* 43210 (OHO00650)
OBJECTIVES: Determine the impact of present and evolving energy policies on agriculture; analyze the economies of selected crop biomass options; delineate the role of agriculture in future energy strategies.
APPROACH: Partial equilibrium market analysis of specific policy issues with identification of non-market effects; production and conversion cost analysis of selected biomass energy options, domestically, in major agricultural exporting countries, and in selected Fourth World countries; and market analysis of international agricultural trade and domestic agricultural resource allocation implications of energy production from biomass as world energy prices rise; identify (from original and/or existing research) mutually comparable measures of cost and important non-market implications (environment, public health and safety, national security) of energy sources, including biomass, which may play significant roles in alternative energy futures; and use this information to identify the cost and non-market trade-offs among selected broad energy strategies which have reasonable likelihoods of being followed.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Ohio

6.0043,

ECONOMIC EVALUATION OF FOREST MANAGEMENT ALTERNATIVES ON HARDWOOD TIMBER TRACTS IN THE NORTHEAST

D.P. Worley, U.S. Dept. of Agriculture, Forest Service, Northeastern Forest Experiment Station, *Columbus, Ohio* 43215 (NE-4202)
OBJECTIVE: Determine the income potential for management of forest lands in Northeast for timber and other uses under a variety of situation comprising different combinations of types, sites, tree characteristics, markets, owner objectives and land management practices.
APPROACH: Improve the awareness of small woodland owners of the income-producing potential of their hardwood stands by developing an automated timber management system for small woodlands. Develop timber quality and value information for planning the economic management of hardwood stands by evaluating existing hard data for sawtimber quality, by developing quality measures for young stands and by initiating studies to test the effect on timber quality development of existing timber management practices. Develop relevant value and price information for forest valuation and management planning by analyzing timber product price changes through time by relating grade lumber markets and prices to outside factors as the CPI and other national economic indicators. Improve the economic information for planning forest protection and for planning forest management for nontimber uses.
PROGRESS: An appreciable acreage of forest land is managed under an uneven-aged system employing selection cutting. Guidelines, both silvicultural and economic in approach, have been developed to provide direction to this type of silviculture. Residual stocking stem distribution, log quality and rate-of-return information from previously reported research for the various species are considered. Trees were selected for cutting first on a silvicultural basis i.e., vigor, species and stem quality. The rate-of-return criteria was then applied to the remaining trees. These trees are to be left or cut depending on how well they meet a set objective i.e., the owner's desired rate-of-return. Trees that earn as much or more will be left to grow. Trees that earn less are to be cut. They are considered financially mature. The desirability of leaving an adequately stocked stand is considered and residual basal areas are suggested. Methods of adjusting the guidelines to actual stand conditions are illustrated. The quality of site and its effect on the economic success of selection cutting has been investigated. The value response after 12 years of selective cutting practices on a low and a high quality site in Appalachian hardwoods.
SUPPORTED BY U.S. Dept. of Agriculture, Forest Service, Northeastern Forest Experiment Station

6.0044,

RENEWABLE SOURCES OF CELLULOSE

W.L. Hughes, Oklahoma State University, Agricultural Experiment Station, Dept. of Electrical Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075
This program attempts to improve the efficiency of photosynthesis for various grasses and other biomass materials so that production of the biomass (to be used in fuel synthesis) can be increased.
SUPPORTED BY Oklahoma State Government

6.0045,

RELATIONSHIP OF AQUATIC FLORA TO WATER QUALITY AND POLLUTION

H.K. Phinney, Oregon State Higher Education System, Oregon State University, Agricultural Experiment Station, Dept. of Botany & Plant Pathology, *126 Agriculture Hall, Corvallis, Oregon* 97331 (ORE00275)
OBJECTIVE: Establish a continuing research program concerning the relation of aquatic flora to the quality of water supplies and water pollution. Determine by biological studies of aquatic habitats, the relation between biotic and edaphic factors that are responsible for changes in the quality of water resources. Coordinate and extend studies presently conducted in the general area of aquatic botany.
APPROACH: Study of the structure of natural aquatic communities existing under varying degrees of pollution. Field and laboratory studies of the metabolic status of these communities. Development of simplified communities under controlled laboratory condition in artificial ecosystems. By use of information obtained in approaches 1-3 the structure of communities of aquatic plants and their metabolic status can be related to variations in individual ecological factors and to human activity.
PROGRESS: The project studying cultural requirements of the hydrocarbon producing alga Botryococcus braunii continues to progress slowly. We have been able to reduce the generation time (time required to double the cell number) from seven days to a little more than five days by manipulating culture conditions. Trials of various different formulations of the culture medium continue. We hope to have some additional definitive results by 1 July 1979. We have begun some initial studies of the question of the causes of the occasional collapse of algal populations growing in and supporting the oxidative capacity of sewage oxidation ponds. Our hypothesis is that bacterial pathogens are responsible for the collapse at least on some occasions. An application for support under the appropriate technology program of the Department of Energy is planned. This problem was the cause of some of the problems experienced during the study of the use of algal mass cultures in the management of swine manure for the recovery of protein and biogas in which I collaborated with Boersma, Miner, Oldfield and Cheeke.
SUPPORTED BY Oregon State Government

6.0046,

NET ENERGY ANALYSIS OF FOREST BIOMASS AS A SOURCE OF ENERGY AND/OR CHEMICALS

P.R. Blankenhorn, Pennsylvania State University, University Park Campus, School of Forest Resources, *102 Ferguson Bldg., University Park, Pennsylvania* 16802 (PEN02369)
OBJECTIVE: Conduct a net energy analysis by balancing the energy inputs for selected forest biomass cultural strategies against the potentiall recoverble (energy outputs) energy for selected biomass conversion strategies in order to recommend a management and conversion strategy with the most favorable energy balance.
APPROACH: A net energy analysis will be performed on selected forest biomass management and energy conversion (or production of chemicals) strategies by balancing the energy inputs against the energy outputs. Criteria will be established for recommending a management and conversion strategy with the most favorable energy balance.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Pennsylvania

6.0047,

SELECTED PROPERTIES OF POPULUS HYBRIDS GROWN FOR USE AS A SOURCE OF ENERGY AND CHEMICALS

P.R. Blankenhorn, Pennsylvania State University, University Park Campus, School of Forest Resources, McIntire Stennis Program, *102 Ferguson Bldg., University Park, Pennsylvania* 16802 (PEN02380)
OBJECTIVE: Determine the clonal variations, as a function of age, among seven Populus hybrids in gross heat of combustion, ash content, macronutrient composotion, and chemical composition.
APPROACH: Wood, bark, and wood'bark specimens, as a function of age, from seven clones of Populus hybrids growing on experimental plots in central Pennsylvania will be obtained for subsequent gross heat of combustion, ash content, macronutrient, and chemical analyses. Variations among the seven clones in the wood, bark, and wood/bark specimens as a function of age will be established and analyzed.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Pennsylvania

6.0048,

CONFERENCE ON CHEMICALS AND MATERIALS FROM RENEWABLE RESOURCES

A. Cruickshank, Gordon Research Conferences Inc., *Pastore Chemical Lab. Annex, c/o Univ. of Rhode Island, Kingston, Rhode Island* 02881 (PFR78-18770)
The purpose of this award is to provide support for the Gordon Conference on 'Chemicals and Materials from Renewable Resources' which is to be held in Wolfeboro, New Hampshire from July 3-7, 1978. This particular conference is a new addition to the long established line of meetings whose purpose is to stimulate research in universities, research foundations, and industrial laboratories. In particular, this conference intends to bring together scientists for multidisciplinary discussions on the production of biomass and its conversion to chemicals and materials.
SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Problem Focused Research

6.0049,

A MULTIDISCIPLINARY RESEARCH PROGRAM DIRECTED TOWARD UTILIZATION OF SOLAR ENERGY THROUGH BIOCONVERSION OF RENEWABLE RESOURCES

W.R. Finnerty, E.I. du Pont de Nemours & Co. Inc., *P.O. Box A, Aiken, South Carolina* 29801 (006996)
The concept of managing higher plants for their fuel value as well as by products has been proposed. This program represents a continuing study of the genetics of pines and sycamores, the biochemistry of oleoresin production in pines, and the biochemistry of methanogenesis from cellulose. Tissue culture propagation of various clonal lines of pines and sycamore enables screening for superior genotypes with enhanced vigor, cold or drought hardiness, and disease resistance. The application of paraquat to pines increases the annual yield of oleoresin. The physiological and biochemical parameters of this phenomenon are amenable to analyses with the expectation that substantiative information about the process will enable more efficacious procedures to be developed for greater optimization of conditions in oleoresin production. The efficient conversion of cellulose to methane by relevant microbial populations requires further research for understanding the physiology and pathway of methane formation in methanogenic and related anaerobic bacteria. Studies involve tissue culture of Pinus elliottii and Platanus occidentalis with correlation to field testing of superior genotypes. Paraquat-stimulated production of oleoresin will be conducted in P. elliottii in both the field and model systems in the laboratory. Established microbial populations converting cellulose to methane will be analyzed at both the microbial and biochemical levels.
RESULTS: Selection of fast and slow-growing clones of sycamores and pines with field testing in progress. Maintenance and propagation of tissue culture systems. A model test system for the biochemical analysis of resin acid synthesis has been developed with tissue macerates of phloem and xylem. The analysis of the seasonal phenology of resin acid production.

Demonstration of biochemical differences between phloem and xylem in resin acid production. Successful stabilization of mesophilic microbial populations which convert cellulose to methane. The involvement of tungsten as an essential component of formic dehydrogenase. Demonstration of high levels of tetrahydrofolate enzymes in methanogenic bacteria.
SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

6.0050,
ENVIRONMENTAL STUDIES, FUEL PLANTATION RESEARCH

J. Stubbs, U.S. Dept. of Agriculture, Forest Service, Southeastern Forest Experiment Station, *P.O. Box A, Aiken, South Carolina* 29801 (EY-76-A-09-0908)
The production of naval stores (rosin and turpentine) is an important resource output from southern forests. Currently over one billion pounds annually go into such major end uses as rosin for paper size, synthetic rubber, adhesives, surface coatings, printing ink, synthetic pine oil, insecticides, pressure sensitive tapes, flavors and fragrances. It has been recently discovered that wounding and treatment of trees with the herbicide paraquat will induce increased oleoresin production. Increased production could lower prices and stabilize supply of rosin and turpentine and their derivatives to the point that they could compete with petroleum, natural gas, and coal tar derivatives as chemical intermediates in the production of many kinds of plastics. This substitution would allow more fossil fuels to be released to satisfy energy needs. Oleoresins themselves could also be converted to fuels. Research is being accelerated and expanded to assess insect pest problems and the protection required, develop sounder insect control and preventive measures, and determine the importance of biological and environmental variables in the process.
SUPPORTED BY U.S. Dept. of Energy, Office of Health & Environmental Research

6.0051,
PROOF OF CONCEPT EXPERIMENTATION, FUEL PLANTATION RESEARCH

J. Stubbs, U.S. Dept. of Agriculture, Forest Service, Southeastern Forest Experiment Station, *P.O. Box A, Aiken, South Carolina* 29801 (EY-76-A-0903)
The objective of this activity is to accomplish research having direct application to the SRP Forest Management Program and to forest management in the Southeast. The research will eventually result in the potential to produce useable biomass with a lower energy expenditure per unit produced. Research studies supported through cooperators in FY 1979 fit into five broad classifications, listed in order of decreasing emphasis: (1) reclamation of drastically disturbed or low productive sites using soil amendments and mycorrhizal treatments, (2) field evaluation of southern pine seedlings selected and bred for resistance to Cronartium fusiforme, (3) reforestation of moderately productive upland sites with Liquidambar styraciflua and various soil amendments, (4) classification of understory plant communities, and (5) recoverable logging residues remaining following timber harvest operations. Most of this research requires several years of tree growth before the effect of treatments becomes apparent. Hence, many of the above projects will continue into FY 1980.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

6.0052,
MANAGEMENT SUPPORT TO FUELS FROM WOODY BIOMASS PROGRAM

R.I. Van Hook, U.S. Dept. of Energy, Oak Ridge National Lab., *P.O. Box X, Oak Ridge Operations Office, Oak Ridge, Tennessee* 37830 (W-7405-ENG-26)
This project is designed to (1) provide technical assistance to the DOE Division of Distributed Solar Technology in developing and demonstrating the technology for economic production and harvesting of woody biomass for energy through support of 27 R and D contractors (university, industry, consulting firms) in 22 states in species screening, stand establishment, improved management strategies, and improved collection-transportation-storage techniques; and (2) develop and maintain an in-house R and D program which complements contractor research in the areas of environmental effects of sewage sludge utilization, nutrient and organic matter depletion associated with forest residue removal, and regional implications of intensive silvicultural practices.
SUPPORTED BY U.S. Dept. of Energy, Office of Energy Technology

6.0053,
FOREST BIOMASS STUDIES

H. Hitchcock, U.S. Tennessee Valley Authority, Div. of Land & Forest Resources, *Norris, Tennessee* 37828
This ongoing project has as its objective the evaluation and analysis of woody forest biomass as related to energy and traditional forest products. Project has two components: (1) construction of individual tree weight equations for forest species, and (2) development of operational biomass inventory techniques. Emphasis is on interagency cooperation.
Funding level is variable and contingent upon cooperators.
SUPPORTED BY U.S. Tennessee Valley Authority, Div. of Land & Forest Resources

6.0054,
PRODUCTION OF SUGAR AND BIOMASS ENERGY FROM SWEET SORGHUM AND SUGARCANE

B.A. Smith, U.S. Dept. of Agriculture, Agricultural Research, Food Crops Utilization Research Lab., *Weslaco, Texas* 78596 (7202-20520-001)
OBJECTIVE: Develop continuous pilot-plant procedures adaptable to factory production of sugar from sweet sorghum and sugar cane, and determine crop potentials for biomass energy production.
APPROACH: Select and adapt continuous pilot-plant processing parameters of temperature, pH, rate, and additive use, in order to provide maximum removals of impurities from juices and syrups derived from mechanically harvested sugar crops. Compare processing procedures for separating impurity-laden sediments from process liquors and determine effect on raw sugar recovery, directing specific attention to separating clarifier mud from filtrate, and aconitate from sweet sorghum syrup. Provide analytical and processing data to assist in selecting superior sweet sorghum and sugarcane varieties and horticultural practices for commercial sugar production and for their potentials as biomass energy source crops.
PROGRESS: Processing tests to determine the effects of leaf-trash on the quality of juices and syrups produced from unburned sweet sorghum stalks revealed that, possibly as the result of the efficiency of clarification and other processing operations necessary to eliminate starch and aconitic acid prior to sugar crystallization, many of the undesirable materials contributed by trash were reduced to tolerable levels, so that various harvesting devices with relatively low efficiencies for removal of trash could be used in commercial sugar operations. Processing tests indicated that a high-speed, continuous centrifuge could be employed satisfactorily for separation of aconitate sediments from syrups in commercial operations, but for separations of juice from insoluble solids in thickened clarifier muds, results were not conclusive. Analytical data from field samples provided Federal and State agencies with information needed to select sugarcane and sweet sorghum varieties suitable for commercial use in this area. Screening of sweet sorghums for biomass energy production revealed that a tropical strain, MN1500, a syrup variety, Sart, and a breeding line, Mer 71-7, have promise for high yields of fermentable carbohydrates and fiber per acre when planted on narrow row spacings. Contributions of carbohydrates and fiber by leaves was of questionable value, and by tops or seed were variable.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Subtropical Texas Area

6.0055,
DEVELOPMENT OF SUGARBEET AND OTHER BETA SPECIES FOR ALCOHOL FUEL PRODUCTION

D.L. Doney, Utah Higher Education System, Utah State University, U.S. Dept. of Agriculture Crops Research Lab., Dept. of Plant Science, *Main Bldg., Office 104, Logan, Utah* 84321 (5702-20090-006)
OBJECTIVE: Evaluate sugarbeet, fodder beet and other representatives of the Beta family for production of total fermentable sugars. Determine cultural practices that will maximize fermentable sugar production with minimal energy input. Develop high-yield, disease-resistant breeding lines for fermentable sugar production.
APPROACH: Evaluate by field test and laboratory analysis existing sugarbeet, fodder beet and other genotypic representatives of the Beta family for fermentable sugar and potential alcohol production. Determine cultural practices, including nitrogen fertilization and plant density, that will maximize fermentable sugarbeet and fodder beet cultivars. Develop, by appropriate breeding and selection methods, improved breeding lines for increased fermentable sugar production with sugarbeet, fodder beet and other Beta types. Incorporate curly-top resistance into high-fermentable, sugar-yielding genotypes.
PROGRESS:
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Idaho - Montana - Utah Area

6.0056,
PRODUCTION OF BIOMASS FOR ENERGY ON ABANDONED FARMLANDS

F.M. Laing, University of Vermont & State Agricultural College, Agricultural Experiment Station, Dept. of Botany, *85 S. Prospect St., Burlington, Vermont* 05401 (VT00905)
OBJECTIVE: Evaluate hardwood trees and shrubs providing highest biomass potential on short cutting cycles. Compare yields from native against introduced species. Evaluate harvesting, transportation and utilization of biomass. Examine portions of yield as potential feed stuff. Model economic comparisons from land preparation to utilization.
APPROACH: In randomized design measure growth rate and sporuting ability for coppice harvest. Include fertilizer and spacing trials. Determine BTU content. Maintain untreated areas of uncultivated species for yield comparisons. Evaluate possible cultivation and harvesting techniques. Compare known transportation and utilization costs with projected acre-yields. Analyze bark and foliage samples for feed value.
PROGRESS: Plot areas have been prepared on differing soil types and at varying elevations for Spring 1979 planting. Candidate hardwood species will be planted for growth measurements. Plant spacings and fertilizer effects, including sewage sludge, will be evaluated. Trials of interplanting of leguminous species with energy species are planned. Growth measurements of coppices in the wild have been made to establish comparative values. Seeds of native trees have been collected and are being stratified for spring germination. Seeds, seedlings and cuttings from commercial sources will also be use in plot trials.
SUPPORTED BY Vermont State Government

6.0057,
PRESSURE HARVESTING OF MICROALGAE

M.D. Fraser, Intertechnology/Solar Corp., *100 Main St., P.O. Box 340, Warrenton, Virginia* 22186 (DAR79-17457)
A reduced pressure method for harvesting cultured microalgae using a low-cost closed-system process will be assessed for technical feasibility in this Phase I small business research project. The method to be tested is an innovative improvement over other more costly and more energy-intensive procedures. An algae-water suspension is allowed to enter a large, closable container; the pressure on the system is first increased causing the algae to concentrate at the bottom, then, on decreasing the pressure the algae rises to the surface and is pumped out.
The success of this research will permit an effective and economically feasible technology for using algae commercially such as for food, wastewater reclamation, and for energy and fertilizer production.
SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Applied Research

6.0058,
A TECHNOLOGY ASSESSMENT OF TERRESTRIAL BIOMASS SYSTEMS

D.J. Salo, Mitre Corp., Metrek Division, *1820 Dolley Madison Blvd., McLean, Virginia* 22101 (PRA78-17621)
Terrestrial biomass is potentially capable of providing a constant supply of significant quantities of fuel and chemicals. There are technologies for biomass production, biomass conversion, and product distribution and utilization systems. Should these technologies be widely adopted and significantly change the present farming patterns, this would lead to important institutional consequences. Issues and impacts which could stem from land acquisition and utilization, biomass fuel and chemical costs, and the effects of biomass technologies on the environment are among those that require assessment. Representative biomass technologies will be selected for assessment and a framework for analysis will be developed. Both technological and nontechnological future impacts will be identified and evaluated assuming a set of baseline conditions.
It is anticipated that private and government decision makers will be utilize the results of the assessment

as they develop policies to cope with impacts of biomass technologies on society. Results of the analysis will be of value in developing investment, commercialization, and research and development programs.
SUPPORTED BY U.S. National Science Foundation, Directorate for Scientific Technological & Internat. Affairs, Div of Policy Research & Analysis

6.0059,
LAND USE IN SOUTHEASTERN U. S. FORESTRY:
W.A. Duerr, Virginia Polytechnic Inst. & State University, School of Agricultural & Life Sciences, McIntire Stennis Program, *Blacksburg, Virginia* 24061 (VA-0632267)
OBJECTIVE: Review major writings on land use relating to forestry in the Southeastern U. S. Interview persons who have knowledge about land use and forestry aspects in the region, identify major land use questions and describe studies to help answer them, test recommendations by carrying out illustrative studies
APPROACH: The starting point will be 360 references already identified. From these a list of relevant questions will be formulated, and these will be placed before a list of interviewees representing state, Federal and local governments, professionals, laymen, and representatives of conservation and other citizens groups. A list of desirable research projects will be compiled. From this list one or more illustrative studies will be carried out.
PROGRESS. Three lines of work are now in progress under this project: (1) studies of the timber-output potential of eastern Virginia forests were initiated because recent Forest Surveys have revealed a declining conifer growing stock. A general plan and a study of timber growth and yield are finished. A study of cordwood output potential is in progress; very tentative indications are that both growth and harvest on the predominant nonindustrial private holdings exceed economically rational levels. (2) A study of state legislative regulation of private forestry practices is finished and will be published by the Southeastern Forest Experiment Station of the Forest Service. (3) Studies of the economics of energy production from wood in the Southeast are in the planning stage.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Virginia

6.0060,
ADAPTATION OF CONVENTIONAL AND NOVEL HARVESTING SYSTEMS TO CHANGING SOUTHERN FOREST CONDITIONS
T.A. Walbridge, Virginia Polytechnic Inst. & State University, School of Agricultural & Life Sciences, McIntire Stennis Program, *Blacksburg, Virginia* 24061 (VA-0632260)
OBJECTIVE: Analyze by mathematical models the response of conventional harvesting machines and systems to terrain and timber harvested; Evaluate forest stand structure, tree engineering characteristics, and product potential of commercially important species in the region; explore novel approaches to silvicultural and raw material needs through harvesting equipment.
APPROACH: Conduct production studies on selected machine and system types across their normal working ranges. Develop mathematical models based on these studies. Then by simulation develop parameters for machines application and document voids in needs by available machines. Determine weights, centers of gravity, and yields of full trees and tree segments for selected commercial trees of the South and Appalachians. Prepare and test through simulation (and field prototypes, if possible) novel machine designs for whole trees, chips, etc.
PROGRESS: The evaluation of temporary stream and drain crossing requirements for skid trails and temporary access roads is nearly complete. A prototype soft crossing structure has been constructed and will be tested in 1979. Analysis of shearing forces required to sever individual and multiple stems during baling of logging residues is in progress. A study of the potential of coppice growth in Appalachian hardwoods to produce biomass for energy has been initiated. A reliability model for feller bunchers and whole tree chippers is being developed to afford maintenance and repair strategies to harvesting personnel. The design of an in-feed mechanism for an in-woods baler for logging residues is complete. A prototype will be constructed in 1979. A study to determine the efficiency of field drying as a method of preparing woody biomass for fuel was initiated. The potential of modifying conventional harvesting systems for the production of fiber and fuel is 50% complete. A comparison of severance devices for complete recovery of woody biomass was initiated. Expected completion date June 1979. A mathematical model of procurement, transportation and storage of woody fuels from forest to plant is being developed. Expected completion is 1980.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Virginia

6.0061,
AQUACULTURE OF SEAWEEDS ON ARTIFICIAL SUBSTRATES
T.F. Mumford, State Dept. of Natural Resources, *Olympia, Washington* 98504 (R/A-12)
LONG-RANGE: To develop commercially feasible aquaculture techniques to grow seaweed used for extraction of useful products, as an energy source, or use directly as food, food supplements, or fertilizer. Techniques for growing seaweeds on artificial substrates placed in tidelands and bedlands will be developed. 1979: 1. Refine techniques for net seeding or Iridaea in tanks. 2. Refine large-scale nets deployed in the field and analyze costs of placement and operation to demonstrate feasibility of pilot-scale project. 3. Continue to identify and quantify factors influencing Iradaea growth (light intensity, nutrients, current, and plant density) in order to maximize productivity. 4. Begin strain selection of Iridaea for fast growing, high-yield plants adapted to local growing conditions. 5. Develop techniques for the culture of local species of Porphyra utilizing methods similar to those used in Japan. 6. Develop market information about edible seaweeds (Laminaria, Cymathere, Nereocystis Porphyra), test samples and begin culture techniques.
ANTICIPATED BENEFITS: This research will benefit the established phycocolloid industry (Marine Colloids, Stauffer Chemical, Genu Products, Litex Products) by providing technology to assure a stable domestic supply of high-quality or specialty seaweeds now in short supply. New local industry will be created by project completion in 1980 in the culturing, harvesting, and processing of seaweeds. Technology developed for the growth of Iridaea on nets may be used for the growth of other seaweeds used for large-scale biomass production for conversion to energy hydrocarbons, foods, pharmaceuticals, etc. This research will enable the Washington State Department of Natural Resources to better manage the seaweed resources of the State. More diverse uses of state-owned tidelands and bedlands and non-exploitative uses of natural populations will be encouraged through aquaculture. Economic return directly to the State will come through several options: 1. Lease of state-owned bedlands and tidelands for seaweed aquaculture. 2. Sale or lease of seeded nets to private companies. 3. Sale or lease of harvesting rights to seaweeds on DNR-owned nets. Personnel will be trained in seaweed aquaculture through employment, student work-study or internship programs. (Text Truncated -Exceeds Capacity)
SUPPORTED BY U.S. Dept. of Commerce, National Oceanic & Atmospheric Admin., Sea Grant Office

6.0062,
EVALUATION AND MODELLING OF BIOMASS YIELDS FROM CONIFER STANDS IN INLAND NORTHWEST
R. Chapman, Washington State University, College of Agriculture, Dept. of Forestry & Range Management, *Pullman, Washington* 99163 (WNP00426)
OBJECTIVE: Development of individual tree biomass equations for each of the major softwood species in the Inland Northwest. Development of statistical models to describe the distribution of biomass within a stand for each tree component (boles, branches, and foliage) based on variety of utilization standards (top diameters), and the accumulation of biomass over time. Modification of existing volume simulators or development of new simulators which can be used to evaluate many alternative energy production stretegies such as optimum species selection and composition and selection of appropriate silvicultural treatments.
APPROACH: Stand representatives of species combinations, age classes and habitat types will be sampled in the field, and lab determinations made of oven dry yield. Statistical models will be designed to provide distribution of biomass within a stand for each tree component. These models will be used to strengthen existing volume simulators or if necessary for the development of new simulators, to evaluate alternative energy production strategies.
SUPPORTED BY Washington State Government

6.0063,
DEVELOPMENT OF BIOCONVERSION PROCEDURES OF AN ENERGY CROP - JERUSALEM ARTICHOKE
R.C. Bailie, Environmental Energy Engineering Inc., *Morgantown, West Virginia* 26505
SUPPORTED BY U.S. Dept. of Energy

6.0064,
ECONOMIC IMPACTS OF ENERGY DEVELOPMENT AND USE ON AGRICULTURE AND NATURAL RESOURCES
V. Whetzel, West Virginia University, School of Agriculture & Forestry, Dept. of Resource Management, *Morgantown, West Virginia* 26506 (NRE-43-309-54-01)
OBJECTIVE: Analyze supply and demand factors that will influence the potential for fuel wood for home heating. Analyze the economic feasibility of energy (biomass) crops, including land and water requirements, impacts on traditional crop production and environmental implications. Assess the economic implications of alternative coal and oil shale development and associated activities on environmental quality and the competition for resources in rural areas.
APPROACH: Asses the economic resource use and environmental implications of public programs to encourage 'energy farms.' Develop regional reports on current land and water use, the economic implications for future resource use, resource competition, and environmental quality resulting from alternative levels of coal and oil shale development, and related activities. Develop an interregion linear program to evaluate conflicting reclamation budgets from available literature, cooperation with other agencies within and without USDA, and limited empirical studies. Budgeting techniques and linear programming will be used to estimate water demand for energy development and to appraise the economic and environmental implications of alternative water supplies.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Natural Resource Economics Div.

6.0065,
PRODUCTION OF SUGARCANE AND TROPICAL GRASSES AS A RENEWABLE ENERGY SOURCE
A.G. Alexander, University of Puerto Rico, Mayaguez Campus, Agricultural Experiment Station, Dept. of Agronomy & Soils, *Mayaguez, Puerto Rico* 00708 (PR-C-00481)
OBJECTIVE: Determine the agricultural and economic feasibility of mechanized, year-round production of dry biomass, through the intensive management of surgarcane and napier grass as tropical forages; examine alternate tropical grasses as potential sources for intensive biomass production; and select and breed new sugarcane clones having superior biomass productivity as their main attribute.
APPROACH: In greenhouse trials, tropical grass species having superior growth potential (on an annual basis and as frequently recut forages) will be identified. Optimal regimes for nitrogen, water, row spacing, harvest frequency, and chemical growth regulators will be defined with superior candidate clones in field plot trials. Mechanization requirements and costs for the two or three superior candiate clones emerging from greenhouse and field-plot experiments will also be evaluated in field trials.
PROGRESS: Tropical grasses from Saccharum and related genera are being evaluated as candidates for intensive production of solar-dried biomass. Categories of candidates include short-, intermediate-, and long-rotation species for intensive co-production with conventional food commodities. Minimum-tillage candidates are also sought for extensive production on marginal lands. The hybrid forage grass Sordan 70-A is the outstanding short-rotation plant tested to date. It completes the tissue-expansion and maturation phases; within 10 weeks, yielding at least 4 tons of oven-dry biomass per acre. Napier grass (var. Common Merker) is a promising intermediate rotation crop which may be exceeded by several napier grass hybrids. Interspecific Saccharum hybrids and the species S. spontaneum and S. sinense are being investigated for long-rotation and minimum tillage cropping. Direct comparisons of sugarcane hybrids with napier grass indicate that sugarcane is an inferior candidate for short-term production of tropical forages. Sugarcane responded well to narrow spacing for about 6 months after seeding. Napier grass failed to respond to close spacing. Both species increased yields with decreasing frequency of harvest. Fertilization rates based on conventional sugar and forage

production data were inadequate to sustain maximum biomass yields.
SUPPORTED BY Puerto Rican Government

6.0066,
METABOLISM IN HIGHER PLANTS UNDER SALINE CONDITIONS
A.J. Joshi, Bhavnagar University, Sir P.P. Inst. of Science, Dept. of Biology, *Bhavnagar 364002, India* (8885)
The problem why all the physiological and biochemical processes in halophytes go on without any hindrance in spite of considerable salts in the habitats is not fully understood. The project envisages the studies on photosynthesis in halophytes with special reference to C3 and C4 pathways and CAM. Seasonal variations in free amino acids and mineral constituents in halophytes in relation to the changing salinity in the habitat will also be studied. During the present investigation preliminary survey will be carried out to find out the halophytic species which can be used for cattle-food, fuel, fibers etc. growing on coastal regions of Saurashtra on western India.
Workplace is a part of a newly established University and facilities are limited. The work on radioactive isotopes will be carried out at places where similar work is being done.
Ecological parameters for terrestrial studies: Latitude, 21 degrees 45 min.; Altitude, 5 meters; Soil types, silty-clay loam; Mean annual temperature, 27.4 degrees C; Months of greatest moisture, June-September; Mean annual rainfall, 656 mm; Mean annual humidity, 64 percent; Number of wet seasons, one.
SUPPORTED BY University Grants Commission

6.0067,
TO DETERMINE THE PERFORMANCE AND SUITABILITY OF TREE SPECIES FOR SALINE AREAS
K.D. Muthana, Central Arid Zone Research Inst., Division of Plant Studies, *Jodhpur, India* (PS/SILVA-2.7)
OBJECTIVES: The natural vegetation is characteristically zerophytic, scanty and chiefly composed of species which are of limited use, extremely slow growing, less productive and are not readily available for use. The parts of arid and semiarid regions of western Rajasthan, Gujarat and Haryana are nonproductive and comprise saline soils and hence there is need to increase the potential productivity of these areas. An investigation, therefore, has to be made for some important indigenous as well as exotic species which can be grown successfully on such saline areas and which can give some returns at short rotation to meet the ever-increasing demand of the local population for fuel, small timber for agricultural implements, fodder, shade and shelter.
APPROACH: 8 species in randomized block design with 3 replications. Each replication will have 8 blocks of 15 x 15 m and the planting distance will be 5 x 5 m in each block there will be 16 plants of each species. A deep trench of 45 cm x 15 cm shall be prepared along the contour line with a slight deviation of 0.1 percent to 0.2 percent to facilitate the drainage of saline water outside the block. The soil dug from trench is made into a mound and the seedling planted on these mound. Species 8: Acacia tortilis, Prosopis juliflora, Tamarix articulata, Salvadora oleoides, Eucalyptus camaldulensis, Acacia nilotica, Albizzia lebbek, Atriplex nummularia.
Ecological parameters for terrestrial studies: Latitude, 26 degrees, 18 min; Altitude, 224 meters; Soil types, sandy loam; Mean annual temperature, 26.3 degrees C; Months of greatest moisture, July-August; Growing season, 70 days; Mean annual rainfall, 366.0 mm; Mean annual humidity, 42 percent; Number of wet seasons, one.
SUPPORTED BY Indian Council of Agricultural Research

6.0068,
LAND-USE IN MANGROVES OF LUWU, SOUTH SULAWESI (PROPOSED PROJECT)
M. Mustafa, Universitas Hasanuddin, Faculty of Agriculture, *Ujung Pandang, Indonesia*
This project will study current pattern of utilization of Mangroves in Luwu and propose development plans which will enhance direct and indirect productivity without loss of stability of resource. Particular attention will be paid to agriculture, fishing and firewood harvesting.
SUPPORTED BY Ministry of Environment

6.0069,
PRODUCTIVITY OF A MANAGED ECOSYSTEM
J.E. Ong, Universiti Sains Malaysia, School of Biological Sciences, *Minden, Penang, Malaysia*
The Matang Mangrove Forest consists of above 30,000 Ha. of managed mangrove forests. Management is basically for the production of charcoal. Trees are presently logged on a sustained yield basis on a 30 years (previously up to 40 years) cycle. There is now an apparent drop in timber production, the exact cause of which is not known. This area also supports a large fishing community (although not all the fishing is within the mangrove area) and economically the return from fishery exceed that from forestry.
This project looks at overall productivity (timber and aquatic) of the mangrove system. Studies include biomass of trees in relation to age, distribution of biomass in relation to age, growth and regneration, litter production, litter breakdown, nutrient cycling, aquatic primary productivity, carbon/nutrient budget.
The managed area offers unique opportunities: tree stands of various known ages are available (0-30 years). There is also a 'Virgin Jungle Reserve' where measuraments of each individual tree above 10 cm GBH have been recorded since the early part of this century.
Ecological parameters for terrestrial studies: Latitude, 5 degrees N; Altitude, sea level; Soil types, mangrove mud; Mean annual temperature, 28 degrees C; Months of greatest moisture, April, November; Growing season, 365 days; Mean annual humidity, 98%; Number of wet seasons, two.
Ecological parameters for aquatic studies: Latitude, 5 degrees N; Water salinity, 0-30 parts per thousand; Water temperature, 27-31 degrees C; Water pH, 6-7.
SUPPORTED BY Universiti Sains Malaysia

6.0070,
INVESTIGATION OF THE COMMON REED (PHRAGMITES COMMUNIS) AS AN ENERGY SOURCE
S. Bjork, Lunds Universitet, Inst. of Limnology, *S22003 Lund 7, Sweden* (53 3065 181)
OBJECTIVE: Initial study to investigate the possibility of using the common reed for energy purposes. Structuring of a research program.
APPROACH: Visits to foreign Phragmites projects, e.g., in Rumania, Iraq, Poland, Germany and the Netherlands. Inventory of the total are of wild Phragmites clones in Sweden. Analysis of possible interest conflicts and environmental protection limits to Phragmites cultivation and harvesting in Sweden. Estimation of the total energy potential and a preliminary inventory of potential areas for Phragmites cultivation. Preparations for cultivation of Phragmites under field conditions.
INTENDED USE OF RESULTS: Results from this project together with project no. 3065 041 will be used in areas with sufficient quantities of wild Phragmites or areas where cultivation of Phragmites is possible. The biomass is intended for use in heating buildings of various sizes. Full-scale experiments (using several thousand tons dried Phragmites) are planned to start around 1980, while the full potential of the project can only be used when suitable methods for cultivating Phragmites have been developed.
SUPPORTED BY Namnden for Energiproduktionforskning

7. BIOMASS, RESIDUES AND WASTES - GENERAL

7.0001,
HEMICELLULOSE RECOVERY AND UTILIZATION
Unknown, Auburn University, School of Engineering, Dept. of Chemical Engineering, *Auburn, Alabama* 36830
SUPPORTED BY U.S. Dept. of Energy

7.0002,
CONVERSION OF CELLULOSIC AND WASTE POLYMER MATERIAL TO GASOLINE
J.L. Kuester, Arizona State University, School of Engineering & Applied Sciences, Dept. of Chemical Engineering, *Tempe, Arizona* 85281 (EY-76-S-02-2982)
The project is aimed at the conversion of cellulosic or waste polymer materials to liquid, transportable fuels. The cellulose source may be from urban refuse, agricultural or forest residues or from crops deliberately grown for energy conversion purposes (land or marine). Since cellulose (biomass) is obtained by photosynthesis (carbon dioxide plus water plus sunlight), the project is solar in nature and the feedstock (plant material) is considered a renewable resource. The process involves decomposing the feed material to basic compounds under the influence of heat (pyrolysis). The basic compounds are then introduced into a chemical reactor where a diesel or jet fuel type material is produced. If a high octane gasoline is desired, a final reaction step is used (reforming).
SUPPORTED BY U.S. Dept. of Energy

7.0003,
FEASIBILITY OF USING RUSSIAN THISTLE FOR BIOCONVERSION
Unknown, University of Arizona, Graduate School, Optical Sciences Center, *Tucson, Arizona* 85721
SUPPORTED BY U.S. Dept. of Energy

7.0004,
EVALUATION AND OPTIMIZATION OF A CELLULOSE WASTE CONVERTER
H.H. Hicks, University of Arkansas, Fayetteville Campus, Schooi of Engineering, Dept. of Mechanical Engineering, *Fayetteville, Arkansas* 72701 (EG-77-S-04-4096)
The investigators will conduct a theoretical and experimental investigation of the Angelo Cellulose Waste Converter concept. The converter is located at a chicken coop manufacuring plant in Jonesboro, Arkansas. The Angelo converter is basically a self-heating rotary kiln that converts cellulose (wood wastes, peanut hulls, rice hulls, cotton gin waste, battery cases, etc.) to charcoal. Off gases are produced that are very clean and steam for generating purposes can be produced. The existing converter will be tested and preliminary design of a prototype demonstration model created. If the testing shows promise, the prototype will be constructed and tested. This project has subcontracts.
SUPPORTED BY U.S. Dept. cf Energy

7.0005,
MACRO ECONOMIC STUDY - BIOMASS VS. COAL
R.T. Mulligan, Bechtel Corp., *50 Beale St., P.O. Box 3965, San Francisco, California* 94119 (B623A-528)
OBJECTIVE: The contractor is to compare multimedia environmental impacts and the cost of clean energy generation from the production and utilization of synthetic fuels from biomass, from biomass energy crops, and from coal.
APPROACH: A report on pollutant emissions and control technology assessment will address the economic and environmental comparisons of coal use versus synthetic fuels from biomass versus using 'energy crops' directly from energy generation.
PROGRESS: The completed report is submitted to the FTB chief.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

7.0006,
CATALYTIC CONVERSION OF BIOMASS TO FUELS AND CHEMICALS
Unknown, Catalytica Associates Inc., *3255 Scott Blvd., Santa Clara, California* 95051 (ET-78-C-03-1883)
SUPPORTED BY U.S. Dept. of Energy

7.0007,
ATMOSPHERIC MEASUREMENTS OF FORMALDEHYDE AND HYDROGEN PEROXIDE
G. Kok, Claremont Colleges, Harvey Mudd College, Undergraduate School, Dept. of Chemistry, *Claremont, California* 91711 (G603A-AD-023)
OBJECTIVE: To measure formaldehyde, hydrogen peroxide, and other pollutants in the ambient atmosphere. To improve the detection sensitivity of a chemiluminescent technique for formaldehyde, and carry out a comparison study of formaldehyde measurements using LPIR and wet chemical methods. To measure formaldehyde and hydrogen peroxide in hydrogen and gasohol fueled vehicles.
APPROACH: Ambient air measurements of hydrogen peroxide and formaldehyde will be made with the recently developed chemiluminescent methods.

Comparisons of formaldehyde measurements will be made with chemiluminescent, wet chemical, and LPIR methods.

PROGRESS: A chemiluminescence method has been developed which measures ambient concentrations of hydrogen peroxide. A system is being developed that measures formaldehyde but its sensitivity needs to be increased to measure low ambient air concentrations.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Environmental Sciences Research Lab.

7.0008,

DESIGN AND FABRICATION OF A MONITOR FOR HCL EMISSIONS IN STATIONARY SOURCES

Unknown, Environmental Data Corp., *608 Fig Ave., Monrovia, California* 91016 (G712B-BA-091)

OBJECTIVE: This task provides for the design and fabrication of HCl monitor which will be used for charactenzation studies at refuse burning steam generating facilities.

APPROACH: The proposed HCl monitor is of the in-situ type and employs the gas-filter correlation measurement technique.

PROGRESS: RFP issued March 16, 1979.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Environmental Sciences Research Lab.

7.0009,

FEASIBILITY STUDY OF FUEL GAS FROM MUNICIPAL REFUSE, CATTLE MANURE AND RESIDUAL SOLIDS

G.B. Humphreys, Kaiser Engineers Inc., Advanced Technology Division, *P.O. Box 23210, Oakland, California* 94623 (EM-78-C-03-2092)

The objective of this study is to determine the technical and economic feasibility of installing a partial oxidation unit (Union Carbide Corporation's PUROX system) adjacent to Kaiser Steel Corporation's plant in Fontana, California. Feed material to the energy and materials recovery facility could include municipal solid wastes, wastewater residual solids, and agricultural (dairy) wastes. The recovered medium-Btu fuel gas would be marketed to either an industrial user, Kaiser Steel, or to Southern California Edison Company, an adjacent power utility. The study area includes San Bernardino County, eastern Los Angeles County, and Riverside County. The project includes waste collection, systems engineering and marketing studies, conceptual design of the facility, cost estimate, and analysis of the institutional factors and economics of the project. A final report will be issued describing the conceptual design and presenting the results of the work performed.

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Office of Conservation, Div. of Buildings & Community Systems

7.0010,

RENEWABLE RESOURCES - ENZYME TECHNOLOGY DIGEST

H. Sobel, Neus Inc., *P.O. Box 1979, Santa Monica, California* 90406 (PFR77-12500)

Enzyme technology and renewable resources are two emerging areas of wide application that are interconnected. Enzyme technology refers to the controlled use of enzymes, biological catalysts, which in turn provide us ultimately with renewable resources used for food, fertilizer, building materials, fuels, chemicals and many other useful materials. These two areas are of interest to both the public and private sectors and to several federal agences including the National Science Foundation. The objectives of this grant is to provide for support to create an informal information exchange, the Renewable Resources - Enzyme Technoloy Digest. The primary objective of this digest is to disseminate pertinent information concerning work in progress at the interface of these two areas.

The digest will be produced four (4) times per year and will be available to the general public on a paid subscription basis.

SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Problem Focused Research

7.0011,

PREPARATION OF COST DATA BANK FOR DOE FUELS FROM BIOMASS SYSTEMS

P. O'Donnell, S R I International, *333 Ravenswood Ave., Menlo Park, California* 94025 (EY-76-C-03-0115-141)

SUPPORTED BY U.S. Dept. of Energy

7.0012,

MISSION ANALYSIS FOR THE FEDERAL FUELS FROM BIOMASS ENERGY PROGRAM

Unknown, S R I International, *333 Ravenswood Ave., Menlo Park, California* 94025 (EY-76-C-03-0115-131)

SUPPORTED BY U.S. Dept. of Energy

7.0013,

LOW BTU GAS TURBINE FOR SOLID WASTE AND BIOMASS

Unknown, State Solid Waste Management Board, *Sacramento, California* 95814

SUPPORTED BY U.S. Dept. of Energy

7.0014,

PRODUCTION OF 2000 TONS OF DENSIFIED REFUSE DERIVED FUEL

K. Cramer, Teledyne National, *9300 Corbin Ave., P.O. Box 805, Northridge, California* 91324 (C818A-S5T24E)

OBJECTIVES: To produce 2000 tons of d-RDF for use as supplementary fuel in coal/d-RDF test burn at General Electric, Erie, Pennsylvania.

APPROACH: 1000 tons to be produced in four months. Additional 1000 tons produced in another four months. All pellets will be 1/2 inch by 1 inch (nominal), produced with a California pellet mill.

PROGRESS: Production rates are much less than anticipated. D-RDF fuel higher quality than previous productions. Transportation costs are very high.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab., Solid & Hazardous Waste Research Div.

7.0015,

WASTE MATERIAL PROCESSES

P.L. Stone, U.S. Dept. of Defense, Navy, Civil Engineering Lab., Naval Construction Battalion Center, *Port Hueneme, California* 93043 (DN687064)

To monitor and evaluate new technology hardware developments by others and to assess their potential for Navy waste-to-energy implementation or application.

On-site observations or short term tests will be made on operating prototypes such as (1) advanced, higher efficiency (65/plus), heat recovery incinerators, and (2) pyrolysis and biological waste-to-energy systems. Storage and combustion tests of a light pyrolytic oil will be made. The concept of firing solid WDF with residual oil will be further evaluated. Transition to 6.3 funding for all above effort by FY 82 is planned.

SUPPORTED BY U.S. Dept. of Defense, Navy, Naval Material Command

7.0016,

CONVERSION OF SOLID WASTE TO POLYMER GASOLINE

J.P. Diebold, U.S. Dept. of Defense, Navy, Naval Weapons Center, *China Lake, California* 93555 (B624B-402)

OBJECTIVE: To determine the feasibility, both technical and economic, of pyrolyzing the organic fraction of municipal solid waste to sufficient quanity of hydrocarbon gases to produce chemical intermediates. Phase I of subsequent studies is directed towards the polymerization of hydrocarbons fraction to liquid fuel suitable for internal combustion engine operation.

APPROACH: 1. An existing pyrolysis unit will be operated under various conditions to maximize the production of unsaturated hydrocarbons. 2. A polymerization unit will be designed, fabricated and added to the pyrolysis unit. 3. Data will be obtained over a wide variety of conditions using the combined pyrolysis and polymerization units. Compositional analysis of pyrolysis and polymerization products will be performed.

PROGRESS: Studies have been conducted with the pyrolysis unit to optimize the unsaturated hydrocarbons in the off-gases. Separate studies have been made on gas cleaning system and a thermal polymerization unit. Polymer gasoline has been produced from the polymerization unit using a combination of bottle gases simulating the gas mixture from the pyrolysis unit.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

7.0017,

DEVELOPMENT OF A LOW BTU GAS TURBINE SYSTEM

W. Lambert, U.S. Dept. of Energy, *1333 Broadway, Oakland, California* 94612 (CC36 -1A50)

OBJECTIVE: To develop a gas turbine electrical generator system that will produce electricity from sludge digester gas or gas from solid waste landfill wells.

APPROACH: 1. Survey low BTU gas sources. 2. Design and fabricate a gas turbine which will operate on low BTU gas. 3. Demonstrate the gas turbine and generator set on a sludge digester gas and landfill gas.

PROGRESS: The survey and most of the design work have been completed.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab., Wastewater Research Div.

7.0018,

METHANOL FUEL MODIFICATIONS FOR HIGHWAY VEHICLE USE

J.L. Keller, Union Oil Co. of California, Dept. of Research, *376 S. Valencia, P.O. Box 76, Brea, California* 92621 (EY-76-C-04-3683)

The aim of this project was to assess the effectiveness of fuel modifications (methanol and higher alcohols) in solving the most important problems brought about by the use of alcohol-based fuels in current IC engines. Extensive physical testing of modified fuels in bench apparatus and in vehicles was the approach to this assessment. A final report draft was submitted March 1978.

SUPPORTED BY U.S. Dept. of Energy, Div. of Transportation Energy Conservation

7.0019,

FUNDAMENTAL CONSIDERATIONS IN THE PREPARATION OF REFUSE DERIVED FUELS

G.J. Trezek, University of California, Berkeley Campus, School of Engineering, Dept. of Mechanical Engineering, *Berkeley, California* 94720 (C818A-S5T023)

The grantee has developed fundamental relationships involved in the size reduction of municipal solid waste (MSW). Additional research has been conducted on fine grinding of MSW. The objective of this research is to explore and develop the theoretical relationships involved in the production of densified forms of refuse derived fuels. The important dependent and independent variables which will fully characterize d-RDF formation will be identified. Experiments will then be performed to measure these variables. Basic relationships will then be developed to help design and predict the performance of a RDF densification process.

PROGRESS: An experimental unit has been installed and preliminary tests are proceeding. Detailed experiments will be pursued during the second year of work. Progress has been delayed because of major damage to the building. Grantee has requested a 12 month no-cost extension.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab., Solid & Hazardous Waste Research Div.

7.0020,

PILOT SCALE EVALUATION OF A GAS PRODUCER FOR THERMAL CONVERSION OF SLUDGE

E.D. Schroeder, University of California, Davis Campus, School of Engineering, Dept. of Civil Engineering, *Davis, California* 95616 (C821B-01TB16)

OBJECTIVE: The objective of the program is to make a pilot scale evaluation of a process to evaluate the 'Application of Packed Bed Gas Producers to the Production of Combustible Gases from Municipal Wastewater Sludges.' The project will consist of the following: 1. Development of a method of making a briquette from municipal wastewater sludge and refuse derived fuel suitable for use in a packed bed gas producer. 2. A pilot scale operation of a packed

bed using the sludge RDF briquettes to demonstrate the unit. 3. The engineering and economic evaluation of the unit and data obtained to determine the suitability of the processes for use as a municipal wastewater sludge disposal method.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

7.0021,

APPLICATION OF PACKED BED GASIFIERS TO THE PRODUCTION OF COMBUSTIBLE GASES FROM MUNICIPAL WASTEWATER SLUDGE

G. Tchobanoglous, University of California, Davis Campus, School of Engineering, Dept. of Civil Engineering, *Davis, California* 95616 (CC36 -IB31)
OBJECTIVE: Determination of the feasibility of pelletizing sludge or sludge and biomass (wastepaper) into pellets and generating a low BTU gas, usable for heating or industrial purposes, from the pellets.
APPROACH: To manufacture pellets from sludge and from sludge and wastepaper and using these as fuel for a gasifier to determine the engineering feasibility and economics of the process.
PROGRESS: A method of pelletizing the sludge and paper has been found and pellets have been made of wastepaper and 15 percent dry solids from sludge. Also, plant species grown on wastewater treatment have been mixed with paper.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab., Wastewater Research Div.

7.0022,

AN ASSESSMENT OF THE END USES OF LIQUID FUELS BIOLOGICAL PROCESSES

P.K. Pefley, University of Santa Clara, School of Engineering, Dept. of Mechanical Engineering, *Santa Clara, California* 95053 (192555 (HRB NO.))
To provide a report describing the end uses of liquids from biomass as energy resources, in both transportation and non-transportation sectors, in support of the OTA study of energy from biological processes.
SUPPORTED BY California State Government

7.0023,

STRAIGHT ALCOHOL TECHNOLOGY

Unknown, University of Santa Clara, School of Engineering, Dept. of Mechanical Engineering, *Santa Clara, California* 95053 (EM-78-C-03-1737)
SUPPORTED BY U.S. Dept. of Energy

7.0024,

SPECIALIZED RESEARCH EQUIPMENT - REFRIGERATED CENTRIFUGE FOR BIOCHEMICAL ENGINEERING RESEARCH

J.C. Linden, Colorado State University, School of Engineering, Dept. of Chemical Engineering, *Fort Collins, Colorado* 80523 (CPE79-26469)
A wide variety of research projects in the area of biochemical engineering require the use of a refrigerated centrifuge. This funding supports the purchase of this type of equipment. The three projects which will make the greatest use of the centrifuge are: 1) low energy pretreatment for enhanced conversion of Lignocellulosic residues to liquid fuels; 2) an engineering study of the regulatory mechanims of cellulose biosynthesis; 3) effects of aliphatic alcohols on cell membranes of Clostridium species.
SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Chemical & Process Engineering

7.0025,

DEVELOPMENT OF TECHNIQUES TO REMOVE LEAD AND OTHER METALS FROM REFUSE-DERIVED FUELS (RDF)

D. Lewis, York Research Corp., *1 Research Dr., Stamford, Connecticut* 06904 (C827B-CWF102)
OBJECTIVE: This study will identify the potential sources of lead in the stack emissions of wastes-as-fuels plants where wastes are combusted for steam or energy production.
APPROACH: Sources of lead such as pigments or lead metal in municipal solid wastes (MSW) will be studied, and MSW-fired plants existing or planned in the next 5-10 years will be assessed for their potential contribution to lead in the environment.
PROGRSS: Sources of lead and other metals in MSW have been studied in Phase I of the study, and Phase II is now underway.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

7.0026,

INVENTORY OF BIOCONVERSION PROJECTS

Unknown, Council on Solar Biofuels, *1717 Massachusetts Ave. N.W., Washington, District of Columbia* 20036
To enable Council to conduct detailed inventory of bioconversion projects already in operation, to identify and describe those offering most promise for wider use, and to prepare status report on processes now at the proof-of-concept stage and on current long-range research in the field.
SUPPORTED BY Andrew W. Mellon Foundation

7.0027,

PRELIMINARY ENVIRONMENTAL ASSESSMENT - TOXIC POTENTIALS OF BIOMASS CHEMICAL FEEDSTOCKS

Unknown, Ebon Research Systems, *820 Quincy St. N.W., Washington, District of Columbia* 20011 (B764B-00927)
OBJECTIVE: The purpose of this report is to define the current status of production and the available environmental control technology for land-based biomass-to-energy systems. The report identifies the air, water, and solid waste discharges associated with biomass production and conversion-to-fuel processes, and discusses methods for pollutant control.
APPROACH: The report identifies the air, water, and solid waste discharges associated with biomass production and conversion-to-fuel processes, and discusses methods for pollutant control. In addition to assessing the degree of environmental control required and available for currently regulated emissions, the report examines the need for control of so-called 'exotic' pollutants.
PROGRESS: Draft report is being reviewed.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

7.0028,

PREPARATION, USE AND COST OF D-RDF AS A SUPPLEMENTARY FUEL IN STOKER FIRED BOILERS

H. Alter, National Center for Resource Recovery Inc., *1211 Connecticut Ave. N.W., Washington, District of Columbia* 20036 (CC2J -CS253)
This Research Grant involves the study of the technical and economic aspects of preparing and using densified forms of municipal solid waste as a supplementary fuel in industrial and institutional stoker coal fired boilers. Investigations are being conducted to establish methodology for preparing densified refuse derived fuel (d-RDF). Process and product characterizations are being developed to enable establishment of specifications for d-RDF. Densification forms will include pellets, briquettes, and cubettes. Independent boiler burn tests and operations are being conducted in conjunction with this research to fully characterize the concept.
PROGRESS: A total of 1200-1500 tons of pellet d-RDF has been produced and combusted in stoker-fed boilers. Production rates were less than machine design capacity; die wear may have caused production problems after 1000 tons. Excess moisture caused poor pellet formation. Observations after approximately one year in storage and after transportation are: pellets degraded to excess fines of 75 percent -pellets still supported acceptable combustion - depending on location, pellets can be stored outside without cover - storage procedures are important - transportation via truck, crop boxes, etc. and use of front end loaders is acceptable - some materials handling experienced at the boiler plant due to deteriorated state.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab., Solid & Hazardous Waste Research Div.

7.0029,

ENERGY FROM BIOLOGICAL PROCESSES

Unknown, U.S. Congress, Office of Technology Assessment, *119 D St. N.E., Washington, District of Columbia* 20510
This study reviews the environmental impacts of production, conversion and use of agricultural products and residues, forage grasses, animal waste, and wood for energy.
SUPPORTED BY U.S. Congress, Office of Technology Assessment

7.0030,

TECHNICAL AND ECONOMIC FEASIBILITY STUDY FOR LOCATING AND OPERATING A SOLID WASTE ENERGY GENERATION AND RESOURCE PLANT

D. Barton, U.S. Dept. of Commerce, *14th & Constitution Ave. N.W., Washington, District of Columbia* 20230
SUPPORTED BY U.S. Dept. of Energy

7.0031,

SOLAR-BIOMASS (BIOCONVERSION) NATIONAL CONFERENCE

R. Shoen, U.S. National Science Foundation, *1800 G St. N.W., Washington, District of Columbia* 20550 (B624B-650)
OBJECTIVE: The objective of this project is to increase the utilization of biomass as an energy source.
APPROACH: This project is to provide partial financial support for an international conference on bioconversion co-sponsored by the EPA and the National Science Foundation. The conference is scheduled for the Atlanta World Congress Center in April 21-24, 1980.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

7.0032,

ADVANCED SYSTEM DEMONSTRATION FOR UTILIZATION OF BIOMASS AS AN ENERGY SOURCE

M. Brown, Wheelabrator Clean Fuel Corp., *2550 M St. N.W., Washington, District of Columbia* 20036 (EG-77-C-06-1036)
SUPPORTED BY U.S. Dept. of Energy

7.0033,

CHARACTERIZATION OF ALCOHOL/GASOLINE BLENDS

R.R. Adt, University of Miami, School of Engineering & Architecture, Dept. of Mechanical Engineering, *Coral Gables, Florida* 33124 (E-(40-1)-5216)
The objective of this project is basic investigation of spark-ignited internal combustion engine operation with alcohol/gasoline blend fuels, including performance, emissions and induction/combustion relationships. Fuels to date have been blends using up to 30 percent chemical grade methanol. Future activities will include fuel-grade methanol and special alcohol/gasoline formulations.
SUPPORTED BY U.S. Dept. of Energy, Div. of Transportation Energy Conservation

7.0034,

CHARACTERIZATION AND ENVIRONMENTAL INVESTIGATION OF DOE'S ANAEROBIC DIGESTION FACILITY

S. Sengupta, University of Miami, School of Engineering & Architecture, Dept. of Mechanical Engineering, *Coral Gables, Florida* 33124 (EV-78-S-05-6072)
SUPPORTED BY U.S. Dept. of Energy

7.0035,

POMPANO BEACH ADVANCED SYSTEMS EXPERIMENTAL FACILITY (ASEF)

Unknown, Waste Management Inc., *Pompano Beach, Florida* 33061 (EY-76-C-02-2770)
Demonstrate a proof of concept scale (50 to 100 TPD) anaerobic digestion plant using the light fraction of urban solid waste and sewage sludge to produce methane rich gas. This effort is to prove the concept of the anaerobic digestion of a mixture of solid waste and sewage sludge, to develop design parameters, to establish economics, and to develop data on the quantity and quality of gas produced. Urban waste is shredded and separated into light and heavy fractions. The light fraction is combined with up to 10 percent sewage sludge and digested. The methane may be used as fuel for power generation in the locality, or cleaned for injection in natural gas lines. While this facility is of near demonstration

size, it will be operated as a true experimental facility to test the effects of parameter variations.

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Office of Conservation, Div. of Buildings & Community Systems

7.0036,

DEVELOPMENT OF DATA FOR SCALE-UP FOR CONTINUOUS PROCESSING OF PYROLYTIC OILS

J.A. Knight, Georgia Inst. of Technology, Engineering Experiment Station, *225 North Ave. N.W., Atlanta, Georgia* 30332 (C818A-05T13)

OBJECTIVE: The broad objective of this program is to maximize the value of pyrolysis oils obtained by pyrolysis of agricultural, forestry, and municipal residues and wastes so that maximum resource recovery and commercial value can be realized from these materials. The specific objective of this phase of the program is to develop the data to design a pilot plant for continuous processing of pyrolytic oils for the production of oil fractions suitable for industrial chemical applications.

APPROACH: Three separation schemes based on current results have been selected for more detailed investigation at the bench level. A single separation scheme will be devised then for intensive testing at the bench level and individual steps will be tested on a continuous basis. In the last phase of the program, a bench scale system will be tested on a continuous basis to develop the necessary data for scaling up the process. The final result will be the design of a pilot plant for testing the continuous processing of pyrolytic oils to produce oil fractions suitable for testing for industrial chemical applications.

PROGRESS: The lab scale studies for the processing of pyrolytic oils have been completed. The scale-up to continuous separation of pyrolytic oils is being accomplished currently.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

7.0037,

DESIGN, FABRICATE AND OPERATE BIOMASS FACILITY

M. Bennett, Georgia Technology Research Inst., *Atlanta, Georgia* 30332 (ET-78-C-01-3060)

SUPPORTED BY U.S. Dept. of Energy

7.0038,

MICROBIOLOGY AND PHYSIOLOGY OF ANAEROBIC FERMENTATIONS OF CELLULOSE

Unknown, University of Georgia, Franklin College of Arts & Sciences, Dept. of Biochemistry, *Athens, Georgia* 30601

SUPPORTED BY U.S. Dept. of Energy, Office of Energy Research

7.0039,

DETERMINE PHYSICAL AND CHEMICAL CHARACTERISTICS OF SYNTHETIC ASPHALT PRODUCED FROM LIQUEFACTION OF SEWAGE SLUDGE

C.L. Lau, Honolulu City & County Government, *650 S. King, City Hall, Honolulu, Hawaii* 96813 (C821B-S1TB23)

OBJECTIVE: Convert sewage sludge into synthetic asphalt by thermochemical aqueous liquefaction. Determine the physical and chemical properties of the synthetic asphalt with regard to application and durability.

APPROACH: Samples of sewage sludge will be liquefied by addition of alkali and reaction at temperatures of 280 to 360 degrees C. The liquid samples will be recovered and distilled, leaving a synthetic asphalt. This material will be examined as a replacement or extender for petroleum asphalt in road paving applications.

PROGRESS: Similar work was done by the Bureau of Mines and others for the production of gas and oil from solid wastes, cellulose, cow manure or sludge. These studies were made for oil and gas production studies. Asphalt, oil and tar were not studied during these previous studies.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

7.0040,

CONVERSION OF LIGNOCELLULOSE BY ACTINOMYCETES MICROORGANISMS

D.L. Crawford, University of Idaho, School of Agriculture, Dept. of Bacteriology & Biochemistry, *Moscow, Idaho* 83843 (PFR78-09453)

Lignin and cellulose are the two most abundant naturally occurring organic materials on earth and potentially represent important industrial raw materials. Further, as a result of man's increased utilization of these resources, they are becoming a major waste disposal problem. An approach to more effective utilization and conversion of lignocellosic materials is biological systems using either intact microbes or possibly isolated enzymes.

Previous research has shown that lignin is degraded by actinomycetes microbes, and a number of active strains have been isolated. The objective of this research project is to characterize the more promising lignin-degrading microbes and to optimize the necessary parameters. In addition, the regulatory relationship of lignin degradation to cellulose hydrolysis is to be examined.

SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Problem Focused Research

7.0041,

REFUSE HEAT RECOVERY

A. Collishaw, U.S. Dept. of Defense, Army, Corps of Engineers, Construction Engineering Research Lab., *Interstate Research Park, P.O. Box 4005, Champaign, Illinois* 61820 (DF409970)

Develop technical criteria and economic data for the design concept of cofiring densified refuse derived fuel (DRDF) and coal in a military scale central boiler plant. Follow-on application of this data will be used to develop design criteria, specification and economic data needed by the military services to cost effectively modify, replace or install new boiler systems that can use DRDF as a primary or supplemental fuel.

There are two phases. The first phase will establish a comprehensive data base on state-of-the-art rdf production, handling and use and identify its potential application to military boiler systems. The second phase will consist of laboratory tests and literature-operational field data gathering for the purpose of developing criteria for designing military scale in-plant RDF storage systems, optional methods of mixing rdf and coal, promising substitution ratios of RDF and coals and criteria for design of waste product disposal systems and pollution abatement. All findings will be used to develop a design concept and protocol for future military application.

SUPPORTED BY U.S. Dept. of Defense, Air Force, Engineering & Services Center, Engineering & Services Lab.

7.0042,

WASTE-DERIVED FUEL (WDF)

S.A. Hathaway, U.S. Dept. of Defense, Army, Corps of Engineers, Construction Engineering Research Lab., *Interstate Research Park, P.O. Box 4005, Champaign, Illinois* 61820 (DA0N8137)

To develop design criteria, specification procedures, and performance acceptance evaluation methods for installation-scale technologies for recovering energy from waste and biomass. A technical report will be prepared giving criteria for the design of modular heat recovery incinerator plants and of handling and storage systems for refuse-derived fuel (RDF) (4th qtr - FY79). A technical report will be prepared identifying near-end and long-term installation-scale biomass-derived fuel technologies (1st qtr-FY80). A technical report will be prepared giving criteria for pollution control and boiler design modifications for RDF use, acceptance testing procedures for modular heat recovery incinerators- and draft engineering instructions for RDF handling and storage system will be prepared (4th qtr - FY80). A technical report will be prepared giving priority application areas for biomass-derived fuel systems (4th qtr-FY81). A technical report giving specification procedures for modular heat recovery incinerators will be prepared- draft guide specifications for production, handling and combustion of RDF will be furnished- and a technical report giving results of an RDF proof-of-concept field test will be provided (4th qtr - FY81). A draft etn will be prepared giving planning and implementation guidance for installation-scale biomass-derived fuel system (4th qtr-FY81).

Data and information will be collected through parallel efforts of analysis of existing installation-scale WDF and biomass systems, laboratory analysis of combustion phenomena, and comprehensive literature review.

SUPPORTED BY U.S. Dept. of Defense, Army, Corps of Engineers, Facilities Engineering Support Agency

7.0043,

ENVIRONMENTAL ASSESSMENT OF SOLAR ENERGY TECHNOLOGIES

S.W. Ballou, U.S. Dept. of Energy. Argonne National Lab., Energy & Environmental Systems Division, *9700 S. Cass Ave., Argonne, Illinois* 60439 (W-31-109-ENG-38)

The overall objectives of the project are to comprehensively examine the environmental and public health and safety impacts resulting from widespread development and utilization of selected biomass energy technologies and to examine regional variations which may facilitate the development and utilization of particular combinations of solar technologies. Specifically ANL will identify and determine the magnitude of residuals on a national and on a per QUAD basis, resulting from each technology at the point of end use, and those residuals associated with the entire systems from raw material extraction to end use municipal sludge, feedlot manures, and forestry and agricultural crop residues will be evaluated as fuel resources for several conversion systems, including an aerobic digestion, pyrolysis, fermentation, and incineration.

SUPPORTED BY U.S. Dept. of Energy, Office of Technology Impacts, Div. of Technology Assessments

7.0044,

EFFECT OF MOISTURE REGIMEN ON SOLID WASTE STABILIZATION

E.S. Chian, University of Illinois, Urbana Champaign Campus, School of Engineering, Dept. of Civil Engineering, *106 Engineering Hall, Urbana, Illinois* 61801 (C818A-S1T07)

OBJECTIVES: The objectives of this study are to determine gas production rates and total quantities from municipal refuse maintained at different steady state moisture conditions, to determine gas production rates and total quantity of gas produced from municipal refuse under transient conditions of moisture content, increase simulating net infiltration at landfill sites, and to determine the quantity of organic matter in leachate draining from the municipal refuse.

APPROACH: A series of modified 55-gallon drums containing shredded municipal refuse serve as the landfill models. Special features include provision for gas and leachate collection, temperature monitoring, uniform water distribution, and self containment for weighing. Four different steady state moisture conditions and three different transient moisture loading rates are to be studied. Additionally, two different ambient temperatures are to be studied. Gas and leachate composition and volumes, and refuse temperature are to be monitored.

OUTPUTS: An interim report describing construction and initial refuse decomposition will be followed by a final report which summarizes the 2-year study. Results will be evaluated to determine the municipal refuse decomposition rates and to quantitatively establish the effect of moisture on the decomposition rate. This information, although obtained on bench scale, should provide valuable basic data for evaluating the performance of field landfills and for development of a model to predict the potential leachate and gas discharges from municipal refuse.

PROGRESS: Moisture control can be used to control decomposition and off-gas production with limited success. Reports have been published in the SHWRD symposia and ASCE EED.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab., Solid & Hazardous Waste Research Div.

7.0045,

REPLACEMENT OF PETROLEUM FUELS WITH ALCOHOL

S.C. Sorensin, University of Illinois, Urbana Champaign Campus, School of Engineering, Dept. of Mechanical & Industrial Engin/Agricultural Engin, *106 Engineering Hall, Urbana, Illinois* 61801 (ER 78-S-02-4745)

Studies are being conducted to increase the possibilities of utilization of alcohols to replace a portion of the U.S. petroleum requirement. Both gasoline and diesel engines are being run with petroleum

fuel/alcohol blends in order to (1) determine optimum conditions for fuel economy and exhaust emissions in a gasoline engine, and (2) study the possibility of using alcohol to modify the physical properties of low-grade fuel oils to make them suitable for use in a diesel engine.
SUPPORTED BY U.S. Dept. of Energy

7.0046,
ECONOMIC FEASIBILITY STUDY OF A WASTE ENERGY CONVERSION FACILITY
A. Dale, Sassi Corp., *241 E. 12th St., Indianapolis, Indiana* 46202 (EM-78-C-01-4235)
SUPPORTED BY U.S. Dept. of Energy

7.0047,
ASSESSMENT OF ENVIRONMENTAL CONTROL TECHNOLOGY FOR SOLAR-DERIVED FUELS
T.A. Austin, U.S. Dept. of Energy, Ames Lab., *Ames, Iowa* 50010 (800200)
The purpose of this project is to identify the obvious and potential environmental impacts associated with using solar derived materials for energy production (biomass conversion processes). Conversion of animal manure to methane gas; crop residues to gas, ammonia or liquid fuels; production of trees or marine crops for energy production; and processing of sawmill waste into fuels are examples of technologies now being developed for conversion of solar derived materials to fuels for energy. This project is designed to provide Environmental Control Technology Division of DOE with sufficient background on the state of the art of these new technologies, to document their obvious and potential environmental impacts and to assess environmental control technologies. The impacts include air pollution, water pollution, and land impacts resulting from both the dispersal of residues remaining after processing and the utilization of the derived fuel. The conversion processes (anaerobic digestion, direct burning, fermentation, and pyrolysis), the disposal of any waste residuals, and environmental impact and required control technologies for the derived fuels will also be investigated. Phase I will provide the state of the art of the technologies involved so that preliminary priorities can be established.
SUPPORTED BY U.S. Dept. of Energy, Office of Health & Environmental Research

7.0048,
SOLID WASTE TO METHANE STUDY, POMPARD BEACH PROJECT
V.A. Fassel, U.S. Dept. of Energy, Ames Lab., *Ames, Iowa* 50010 (003109)
The objective of this project is to evaluate the possible environmental problems associated with the anaerobic digestion and production of methane from urban waste. In particular the effluent streams from the digestor will be characterized so that proper disposition can be recommended. Emphasis will be placed on possible ground water contaminants. Exit streams sampled will include the methane product gas, the filter cake and the filtrate. Major, minor and trace element levels will be determined. Microbiological characterization will include both bacterial and viral identification. Major classes of organic compounds present will be identified with more detailed analysis performed where needed. Since the carcinogenic level of the effluents is of major concern, an overall evaluation will be made using the Ames mutagenicity test. The specific issue within the water quality subtechnology is the possible contaminant of the ground water from digestion of urban waste as the most important concern. Other specific issues include characterization of aromatic and aliphatic hydrocarbons, major, minor and trace metals and pathogens.
SUPPORTED BY U.S. Dept. of Energy, Office of Health & Environmental Research

7.0049,
ENVIRONMENTAL CONTROL TECHNOLOGY REQUIREMENTS IN SOLID WASTE PROCESSING AND ENERGY RECOVERY FACILITIES
J.C. Young, U.S. Dept. of Energy, Ames Lab., *Ames, Iowa* 50010 (800121)
The purpose of this project is to identify obvious and potential water use and water pollution problems at facilities designed and operated to process municipal solid wastes for the purpose of energy or resource recovery, to characterize the treatability of these wastewaters, and to identify available methods and their adequacy for treating these wastewaters. The overall objective is to assess the adequacy of environmental controls for meeting existing and projected water pollution control requirements.
SUPPORTED BY U.S. Dept. of Energy, Office of Health & Environmental Research

7.0050,
ANAEROBIC DIGESTION OF HIGH BOD WASTES FROM PYROLYSIS PROCESSES
R. Dague, University of Iowa, School of Engineering, Dept. of Environmental Engineering, *Jessup Hall, Iowa City, Iowa* 52240 (EY-77-C-02-4455)
Anaerobic digestion as an alternative to activated sludge treatment process for treating the effluent from pyrolysis plants. The process is expected to produce a net gain in energy in the form of medium Btu gas.
SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Office of Conservation, Div. of Buildings & Community Systems

7.0051,
DEMONSTRATION OF THE THERMOPHILIC AEROBIC-ANAEROBIC DIGESTION PROCESS AT THE CITY OF HAGERSTOWN
M.G. McGauhey, Hagerstown City Government, Water Pollution Control Unit, *Hagerstown, Maryland* 21740 (C824B-S1TA49)
OBJECTIVE: The water pollution control unit proposes to make available its anaerobic digester and sludge handling facilities in a research study to improve sludge digestion and increase gas production. The unique feature of the study is the combining of an aerobic digester of new design, with an existing anaerobic digester operating both as a unit process.
APPROACH: Raw sludge will be fed the aerobic digester producing excess heat which can be used to heat the sludge digesting in the anaerobic digester. Several advantages will occur: shorter retention times, production of a pasteurized sludge, greater gas production, and the achievement of better stabilization of the sludge.
PROGRESS: Units still under construction.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

7.0052,
WATER PULSEJET ENGINE AND PUMP
P.R. Payne, Payne Inc., *Annapolis, Maryland* (EG-77-C-01-4121)
An externally heated engine, employing a modified Rankine cycle, and in its simplest embodiment, having no moving parts. The basic engine is known as the water pulsejet. Applicable to boat (ship) propulsion and water pumping in its simplest forms. For boat propulsion, predicted efficiency is comparable with a diesel driving a water propeller; cost is two orders of magnitude less. Small propulsion engines have already been demonstrated, powered by open flame (propane, wood, agricultural refuse, etc.) Also has applications in transferring heat, as a heat pipe substitute. Transfer of 10 Kw over 8 feet by an 0.875 inch I.D. pipe has been demonstrated without any indication that this is near an upper limit for either heat loading or distance.
SUPPORTED BY U.S. Dept. of Energy, Div. of Solar Technology

7.0053,
REFUSE-DERIVED FUEL (RDF) AS A SUPPLEMENTAL FUEL IN CEMENT KILNS (MODIFICATION/ADD-ON TO EXISTING IERL GRANT)
C.R. Willey, State Environmental Service, *60 West St., Annapolis, Maryland* 21401 (C818A-S5T24D)
OBJECTIVE: To determine optimal processing techniques for preparing MSW into a suitable fuel for adding to cement kiln coal fuel for the purpose of disposing of the wastes and reclaiming fuel value, thus saving on coal fuel costs.
APPROACH: Single and multiple-stage shredding with different shredders and metal and glass removal inbetween stages are being studied, coupled with burn-tests at production cement kilns.
PROGRESS: To date, it has been determined that double shredding to approx. 1 to 1 1/2 inch particle size is sufficient to burn the MSW/RDF efficiently in the kilns, using a vertical and horizontal hammermill to prepare the RDF.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

7.0054,
HEATING VALUE MEASUREMENTS ON REFUSE DERIVED FUELS
J.G. Berke, U.S. Dept. of Commerce, National Bureau of Standards, National Measurement Lab., *Rte. 270, Gaithersburg, Maryland* 20234 (50611)
OBJECTIVE: To construct and operate a large scale calorimeter facility. To carry out research on measurements on refuse derived fuels. To carry out research on material problems such as refractory integrity, lifetimes of grates, particulate emissions and sampling of wastes and waste products.
SUPPORTED BY U.S. Dept. of Commerce, National Bureau of Standards, National Measurement Lab.

7.0055,
CHARACTERIZATION OF ENERGY FROM WASTE
J.G. Berke, U.S. Dept. of Commerce, National Bureau of Standards, National Measurement Lab., *Rte. 270, Gaithersburg, Maryland* 20234 (50610)
OBJECTIVE: To design, develop, construct and operate a large scale combustion calorimetry facility to carry out research on measurements and other technical needs related to fuels, material properties, environmental problems associated with energy recovery from wastes destined for disposal.
SUPPORTED BY U.S. Dept. of Commerce, National Bureau of Standards, National Measurement Lab.

7.0056,
RESOURCE RECOVERY FROM PROBLEM WASTES
W.J. Campbell, U.S. Dept. of the Interior, Bureau of Mines, Metallurgy Research Center, *Avondale, Maryland* 20782 (B-17-I)
Identify, characterize, and assess the resource recovery potential of industrial wastes classified as hazardous by the Environmental Protection Agency, or wastes generated as a result of implementation of new pollution control measures to comply with new standards and regulations.
Industrial wastes being classified as hazardous by the Environmental Protection Agency or other regulatory agencies, and wastes being generated as a result of new pollution control measures may contain recoverable quantities of metals and minerals. Identification and characterization of these wastes could not only lead to an assessment of resource recovery potential and possible offset of environmental control expenses, but may also result in more environmentally compatible disposal procedures than are now practiced. Research groups within the Bureau of Mines have been looking at industrial wastes for many years, and duplication of effort will be avoided. However, many waste materials pose unresolved problems and these are the wastes that will be emphasized, drawing upon the expertise and experience already existing within the Bureau. The exploratory appraisals conducted are not necessarily intended to resolve the problems, but will hopefully define the problems and lay the groundwork for future Bureau projects. The first year will be devoted primarily to gathering information; establishing working relations with regulatory angencies, research groups, and appropriate industries; and completing the work begun in FY 1976 on the environmental evaluation of the combustible fraction of municipal solid waste as an energy source, and on resource recovery from incinerated sewage sludges.
SUPPORTED BY U.S. Dept. of the Interior, Bureau of Mines, Avondale Research Center

7.0057,
BIOCONVERSION OF BIOMASS GASIFER PRODUCT GASES TO ORGANIC CHEMICALS
D.L. Wise, Dynatech Corp., *Cambridge, Massachusetts* 02114 (PFR7816404)
The prevaling popular approach to the biological conversion of biomass to chemicals is to enzymatically hydrolyze the raw materials to sugars which are then fermented to a variety of useful chemical products. This award will investigate an alternative approach which is to first gasify the biomass and then convert the resulting gases, CO, CO2, and H2 to organic chemicals by anaerobic fermentation. The proposed research will pursue four tasks: 1. To select and isolate microbial cultures which convert CO, CO2, and H2 to useful chemicals, 2. To characterize and identify the cultures, 3. To determine the range of products formed under varying environmen-

tal conditions. 4. To validate the results in laboratory scale fermentors.
SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Problem Focused Research

7.0058,
ENGINEERING EVALUATION OF PROGRAMS TO RECOVER FUEL GAS FROM WASTE
D.L. Wise, Dynatech Corp., *Cambridge, Massachusetts* 02114 (EY-76-C-02-2991)
SUPPORTED BY U.S. Dept. of Energy

7.0059,
BIOMETHANATION OF LOW BTU GAS FROM PYROLYSIS OF SOLID WASTE
D.L. Wise, Dynatech Research & Development Co., Dept. of Chemical Engineering, *99 Ene St., Cambridge, Massachusetts* 02139 (DOE-4)
This project is designed to evaluate, on an economic basis, the process of biomethanation of low Btu gases from pyrolysis of solid waste. In so doing, it will provide the basis for assessing the competitiveness of this process with existing alternatives. The biomethanation process uses simple anaerobic fermentation of pyrolysis gases to produce a pipeline quality gas. This is in comparison to existing methods which involve high temperature catalytic methods with precise process control. A detailed engineenng cost analysis of the biomethanation process will be carried out. In particular, a PUROX type unit will be employed as a source of medium Btu gas. The PUROX unit considered will process 1000 to 5000 tons per day of municipal solid waste. Factors to be considered include capital requirements, operating costs, energy balance, necessity for further gas cleanup, and resultant unit gas prices. In addition, the following comparisons will be made: PUROX plus biomethanation, PUROX plus normal methanation route, and direct anaerobic fermentation. At the completion of the task, the contractor will produce and submit to DOE an engineering report with a full process description, the detailed economic analysis including documentation of all cost source data, and the total capital requirements, operating costs, and a unit gas price for each of the process combinations mentioned above.
SUPPORTED BY U.S. Dept. of Energy

7.0060,
LOW TEMPERATURE THERMOCONVERSION OF BIOMASS TO USEFUL CHEMICALS BY LEWIS ACID CATALYSTS
V.R. Koch, E I C Corp., *55 Chapel St., Newton, Massachusetts* 02158 (PFR79-17513)
The sharp rise in price and uncertain availability of hydrocarbon feedstocks make biomass an attractive candidate as a source of useful organic chemicals. Biomass may be converted to alcohols, ketones and acids with high selectivity but at low rates; thermoconversion of biomass proceeds at high rates but with no selectivity.
The goal of this project is to convert biomass into useful organic chemicals at reasonable cost. Specific objectives are to confirm the presence of pyrone by spectroscopic techniques and elemental analysis; identify the threshold temperature for pyrone formation with AlCl3; determine useful temperature range for pyrone generation; and assess pyrone yield as a function of temperature and amount of AlCl3 catalyst.
This research project resulted from responses to NSF Program Solicitation 78-69, 'Small Business Innovation Research.'
SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Problem Focused Research

7.0061,
EMISSIONS ASSESSMENT FROM REFUSE-DERIVED FUEL COMBUSTION (ERCO)
R. Derham, Energy Resources Co. Inc., *185 Alewife Brook Pkwy., Cambridge, Massachusetts* 02138 (B827B-875)
OBJECTIVE: The objective of this project is to characterize the emissions from cofiring 3 types of refuse-derived fuel with coal in a fluidized bed combustion unit.
APPROACH: Fuels from CEA, Ames, Iowa, and Milwaukee are being burned with an Illinois coal. A source assessment sampling system (SASS) is being used to determine criteria pollutants, trace metals, and selected organics.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

7.0062,
DEGRADATION OF CELLULOSIC BIOMASS AND ITS SUBSEQUENT UTILIZATION FOR CHEMICALS PRODUCTION
D.I. Wang, Massachusetts Inst. of Technology, School of Science, Dept. of Nutrition & Food Science, *77 Massachusetts Ave., Cambridge, Massachusetts* 02139 (EG-77-5-02-4198.A000)
This is a coordinated program to effect the microbiological degradation of cellulosic biomass and the subsequent utilization of the degradation products to produce chemical feedstocks. The microbiological aspects of cellulosic biomass degradation will focus on the use of anaerobic microorganisms which possess cellulolytic enzymes. These studies will attempt to increase the enzyme levels through genetics, mutation and strain selection. In addition, the direct use of these cellulolytic anaerobes to produce soluble products (sugars) which can then be utilized by other micrcorganisms to produce chemicals is also within the scope of this program. Engineering scale-up of these microbial processes is planned once the basic microbiological parameters are defined. The second area of our major effort is devoted to the production of chemical feedstocks. In particular, three fermentations have been identified for exploration. These are: acrylic acid, acetone/butanol and acetic acid. The main efforts in these fermentations will address means for the reduction of the cost of manufacturing for these large volume chemicals.
SUPPORTED BY U.S. Dept. of Energy

7.0063,
ENZYMATIC SACCHARIFICATION OF CELLULOSE TO PRODUCE CHEMICALS AND LIQUID FUELS
M. Mandels, U.S. Dept. of Defense, Army, Natick Research & Development Command, *Natick, Massachusetts* 01760 (DA0H4301)
To carry out laboratory research on cellulase production and saccharification of waste cellulose by cellulase that will lay the foundation and define the parameters for a practical process.
Investigate the physiological, biochemical, and genetic factors involved in induction, synthesis, and secretion of the enzyme-utilize this information to maximize cellulase yields- study the interactions of the cellulase enzymes with their substrates, including the effects of levels of the various enzyme components, effects of inhibitors including the products of the reaction, and the effects of cellulose structure, degree of crystallinity, and admixture with impurities such as lignin on the rate and extent of the hydrolysis reaction- and utilize this information to maximize sugar yields.
SUPPORTED BY U.S. Dept. of Defense, Army, Natick Research & Development Command

7.0064,
ENZYMATIC HYDROLYSIS
R. Lester, U.S. Dept. of Defense, Army, Natick Research & Development Command, Natick Lab., *Natick, Massachusetts* 01760 (EC-77-A-31-1007)
Convert cellulose in urban wastes to glucose with further fermentation to alcohols and other energy products. Enzymatic hydrolysis involves the enzymatic conversion of celulose to glucose which can subsequently be converted to a food, used directly as a petroleum substitute to produce chemical intermediaries, or fermented to ethanol. DOE supported efforts to develop this project to full scale at the U.S. Army Natick Laboratory in FY76. During FY78, various methods of size reduction will be investigated for energy and fiscal economy and the prepilot plant will be operated to increase the cellulose feed and production concentrations. Project is managed by a series of milestones and objectives which could result in major modification of duration and planned dollar value.
SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Office of Conservation, Div. of Buildings & Community Systems

7.0065,
ENZYMATIC CONVERSION OF RENEWABLE BIOMASS TO ALCOHOL FUELS
Unknown, Canby Area Vocational Tech. Inst., *Canby, Michigan* 56220
SUPPORTED BY U.S. Dept. of Energy

7.0066,
BACTERIAL TRANSFORMATION OF LIGNIN
R.L. Crawford, University of Minnesota, Minneapolis Campus, Gray Freshwater Biological Inst., *P.O. Box 100, Navarre, Minnesota* 55392 (PFR79-06772)
Lignin and cellulose are the two most abundant naturally occurring organic materials on earth and potentially represent important industrial raw materials. Further, as a result of man's increased utilization of these resources, lignocellulosic materials are becoming major waste disposal problem. The objective of this two-year project is to assess the effectiveness of bacteria for converting lignin in agricultural- and forest-derived lignocellulosic materials to useful products. Specific objectives are to genetically modify lignin-degrading bacteria to produce catabolically blocked mutants, use the blocked mutants to map the catabolic pathways and produce novel lignin-containing compounds.
This project is a two-year continuation of NSF grant AER 76-22254.
SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Problem Focused Research

7.0067,
TECHNICAL, ENVIRONMENTAL AND ECONOMIC CO-DISPOSAL SYSTEM RESEARCH
B. Boo, Western Lake Superior Sanitary District, *325 Lake Ave. S., 603 Meierhoff Bldg., Duluth, Minnesota* 55802 (C821B-01TB13)
OBJECTIVE: To evaluate the first fluidized bed municipal wastewater sludge incinerator that will use refuse-derived fuel instead of fossil fuels to burn the sludge.
PROGRESS: The plant is expected to operate in May 1979, when the evaluation can be started.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

7.0068,
REFUSE DERIVED FUEL SOURCES AND UTILIZATION
A.D. McElroy, Midwest Research Inst., *425 Volker Blvd., P.O. Box 27-303, Kansas City, Missouri* 64180 (B624B-T6001)
OBJECTIVE: The objective of this study is to identify sources of feedstocks (wastes) compatible with existing waste-as-fuel processes and 'product' fuel users. This effort calls for a national identification of waste sources and current fuel users.
APPROACH: The contractor utilized his experience and existing data to accomplish this task.
PROGRESS: Now have a draft final report.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

7.0069,
ECONOMIC ANALYSIS OF THE IMPACTS OF COAL DEVELOPMENT IN MONTANA
R.L. Stroup, Montana State University, Agricultural Experiment Station, Dept. of Agricultural Economics, *Bozeman, Montana* 59715 (MONB00075)
OBJECTIVE: Coordinate present and expected coal development research within the Department of Agricultural Economics and Economics and between the Department researcher effort and other researchers, funding agencies, and potential users of the data outputs. Conduct economic analysis on one or more problems posed by coal development to Montana Agriculture and rural development, with initial priority on the question of strip mine reclamation.
APPROACH: Coordination implies keeping abreast of coal research developments including the activities of other researchers, funding agencies, and data users. Economic analysis of reclamation alternatives will be approached on the cost side of cost synthesis, in a fashion similar to farm budgeting studies; methodology for approaching other unresearched and important questions remains to be determined.
PROGRESS: Two versions of a report were completed on the Gasohol feasibility project, including preparation of a version for the Montana Business Quar-

terly. On an unsubsidized basis, Gasohol was shown to be infeasible due to high energy requirements and other costs. Supervision of a masters thesis on residential electricity rates in Montana also was completed, and work on a summary report, for public release, was begun. The thesis estimated that nearly half of the residential electricity consumption (and coal strip power plant mine development) projected for the year 2000 can be avoided if consumers are faced with an incremental cost rate structure. A previous report on competition for water among farmers, industry, and other users was updated and accepted for publication.
SUPPORTED BY Montana State Government

7.0070,
PYROLYTIC CONVERSION OF LIGNOCELLULOSIC MATERIALS
F. Shafizadeh, University of Montana, School of Arts & Sciences, Dept. of Chemistry, *770 Eddy St., Missoula, Montana* 59801 (PFR78-18096 A01)
This award, a supplement to NSF grant PFR78-18096, is for the purpose of providing additional manpower and necessary equipment to pursue the recent and unexpected result obtained in the hydrolytic studies on cellulose. Specifically, the finding is that wet-milling cellulose with the cellulose enzymes produce twice as much glucose as that obtained from ball-milled cellulose and four times as much glucose as that obtained from the untreated substrate. This method of hydrolysis could improve the economic feasibility of converting cellulose to glucose.
The supplemental support provides additional support for one postdoctoral student and for an attritor mill. The scope of the overall project has not changed, and this support augments the previously supported research on treatments to increase the susceptibility of cellulose to enzymic hydrolysis.
SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Problem Focused Research

7.0071,
ACID HYDROLYSIS OF CONCENTRATED SLURRIES OF CELLULOSIS BIOMASS
Unknown, Dartmouth College, Graduate School, *P.O. Box 833, Hanover, New Hampshire* 03755 (EG-77-S-01-4061)
SUPPORTED BY U.S. Dept. of Energy

7.0072,
ASSESSMENT OF COMMERCIAL SCALE BIOCONVERSION DEMONSTRATION FACILITY
R.J. Watson, John G. Reutter Associates, Dept. of Project Management, *9th & Cooper Sts., Camden, New Jersey* 08101 (EM-78-C-01-5213)
The objectives are to develop methodologies for commercial scale-up of 100 TPD RefCOM Bioconversion Pilot Plant operating at Pompano Beach, FL, and locate optimal sites for such a plant in NJ. This plant recovers methane gas by anaerobic digestion of shredded municipal solid waste and sewage sludge. Document will be prepared on the state-of-the-art of bioconversion technology by assessing past and current research and pilot plant work. We will also develop site selection criteria, as well as identify and screen potential locations for a 500 to 2000 TPD plant. The expected result is a concept design and implementation plan for the first full scale bioconversion plant.
SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Div. of Solar Energy, Office of Solar Application for Buildings

7.0073,
ENERGY AND ENVIRONMENT POLLUTION
R. Manganelli, Rutgers the State University of New Jersey, New Brunswick Campus, Agricultural Experiment Station, Dept. of Environmental Sciences, *Old Queens Bldg., New Brunswick, New Jersey* 08903 (NJ07490)
OBJECTIVE: Study factors affecting the improvement of combustion and energy conversion relative to formation and change of various pollutants. Evaluate energy conservation and useage in existing, new and proposed air and wastewater treatment operations.
APPROACH: Procedures will involve laboratory and field investigations in the use of various types of solid and liquid fuels, in method of air and wastewater treatment, in methods of energy balance in treatment and disposal of wastewater and sludges, in methods of combustion of various sludges for energy production.
SUPPORTED BY New Jersey State Government

7.0074,
DEVELOPMENT OF A UNIQUE ALL-BIOLOGICAL CONVERSION PROCESS FOR THE PRODUCTION OF ETHYL ALCOHOL FUEL FROM PLANT BIOMASS
W.D. Bellamy, General Electric Co., *1 River Rd., Schenectady, New York* 12305 (EG-77-C-02-4147)
SUPPORTED BY U.S. Dept. of Energy

7.0075,
APPLICATION OF 'RAPID FERMENTATION' TO THE PRODUCTION OF PRODUCTS FROM CELLULOSIC WASTES
K.H. Steinkraus, New York State Agricultural Experiment Station, *Geneva, New York* 14456 (NYG23363)
OBJECTIVE: Apply the principles of 'rapid fermentation' to the practical production of cellobiose and/or glucose from cellulosic substrates, particularly wastes such as straw, waste paper, and sawdust. Utilize the cellobiose/glucose directly in the manufacture of useful fermentation products.
APPROACH: Trichoderma viride, Cellulomonas sp., Myrothecium sp., Chaetomium sp., Neurospora crassa all cellulase producers, will be applied to crude cellulose substrates including straw, waste paper, and other cellulosic wastes. The 'rate' i.e., the number of glucose molecules produced from the cellulose per cell (or per unit cell weight) per second will be determined. Then the number of cells required to produce the rate of reaction desired will be determined. Then the % of total available cellulose hydrolyzed in a given time interval will be determined. Present processes for cellulose hydrolysis require generally several days making the use of cellulose rather impractical. Initially, the objective will be to reduce fermentation time to less than 24 hours and then to reduce the total time required to 10 hours or less.
PROGRESS: 'Rapid' fermentation was originally applied to fermentations in which ethanol content in high sugar (up to 25% W/V) substrates rose from 0 to 12% ethanol V/V in 6 hours or less. It has been found that 'rapid' fermentation can be accomplished raising the ethanol content from 0 to 17% V/V in 12 hours. The substrates used have been either molasses or malt syrup (2% v/v). Sucrose was added incrementally 2% W/V at 30-minute intervals. Temperature was maintained at 20 degrees C. Oxygen tension was maintained at about 13% dissolved oxygen. Yeast concentration was approximately 109 cells/ml. Yeast cells lost their viability as ethanol content rose to the high levels. 'Rapid' fermentation applied to culture of Trichoderma viride on 1% w/v cellulose (solka-floc) has yielded 0.45 grams of cells per gram cellulose fermented in 48 hours at 30 degrees C. At that juncture, yield of cells is approaching theoretical. Soluble protein at two days (a measure of cellulase produced) was 1.5 mg/ml. Upon continued incubation, soluble protein rose to 1.9 mg/ml on the 8th day.
SUPPORTED BY New York State Government

7.0076,
CONTINUOUS TWIN SCREW ACID HYDROLYSIS REACTOR DEVELOPMENT AND OPTIMIZATION FOR ONE-TON DAY WASTE CELLULOSE GLUCOSE PILOT PLANT
W. Brenner, New York University, Washington Square & University College of Arts & Sciences, Dept. of Applied Science, *100 Washington Sq. E., New York, New York* 10003 (C827B-C2T903)
OBJECTIVE: Acid hydrolysis of waste cellulose is potentially very attractive because cheap glucose would be a most useful intermediate for chemicals and energy production. Technical problems such as low glucose yields and long reaction times have prevented large scale usage. The purpose of this study, then, is to maximize glucose production from cellulosic wastes using a process of selected pretreatment of cellulosic wastes followed by rapid, high temperture acid hydrolysis.
APPROACH: A 3-year program of experimental investigations is proposed on the additional development and optimization of the continuous twin screw acid hydrolysis reactor for the establishment and operation of a one-ton/day waste cellulose-glucose pilot plant. This program encompasses: (1) the identification of all pertinent acid hydrolysis equipment; (2) procurement and installation; (3) optimization of operating conditions including waste cellulose feed preparation and glucose recovery; (4) product quality analysis; and (5) determination of environmental impact with maximum energy conservation. Initial optimization will be carried out with waste newspapers. The experimental work will be supplemented by a detailed economic cost analysis with subsequent projections for various larger production scale-ups.
PROGRESS: The design and installation of the one-ton/day hydrolysis plant has been completed. Optimization of this facility is ongoing.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

7.0077,
ECONOMIC FEASIBILITY AND POTENTIAL OF PRODUCING AND USING ALCOHOL BLENDS IN NEW YORK STATE
W. McShane, Polytechnic Inst. of New York, Brooklyn Campus, School of Science & Engineering, Dept. of Transportation Engineering, *333 Jay St., Brooklyn, New York* 11201 (177836 (HRB NO.))
To perform an assessment of the economic feasibility of producing various alcohols (methanol, ethanol, etc.) to be blended with gasoline and used as a fuel in existing automobiles (i.e. without any mechanical adjustments). The project will review distillation technologies. Sources of biomass, raw materials, interaction with petroleum producers and retailers, and acceptance of blended fuel by public. A workshop/seminar on alternative fuels will be executed, with potential users of several types as participants. Particular attention is being paid to competing uses.
SUPPORTED BY New York State Government

7.0078,
FERMENTATION INTERACTIONS IN MICROBIAL ECOSYSTEMS
M.J. Wolin, State Div. of Lab. & Research, Environmental Microbiology Section, *Empire State Plaza, Albany, New York* 12237 (R01 AI 12461-06)
Pure cultures will be studied singly and in combination to elucidate how organisms interact to produce characteristic fermentations of complex, anaerobic, microbial ecosystems. The studies will focus on mammalian gastro-intestinal fermentations and anaerobic waste decomposition. Previous investigations showed that H2-using species can increase formation of H2 and alter fermentation products of major saccharolytic rumen species. These studies will be extended to other H2-producing saccharolytic species of the rumen, the human large intestine and to organisms that produce H2 from non-carbohydrate sources. Interactions between cellulose- or starch-hydrolyzing species and non-polymer fermenting species will be examined. The latter organisms use soluble sugar intermediates produced from the polymers. catalogue of species capable of interaction will be prepared and the amount of competition for hexose will be estimated. Models of the various ecosystem fermentations will be prepared by mixing selected pure cultures. To model the systems that completely convert organic carbon to CH4 and CO2, the nutrition of the only pure culture known to convert acetate to CH4 and CO2 will be studied, and isolation of new species will be undertaken. Changes in growth rate, controlled by limiting carbohydrate in a chemostat, markedly change the fermentation products of certain bacteria by affecting paths of pyruvate catabolism. Studies will be extended to other species with alternate paths of pyruvate catabolism to examine the generality of the phenomenon. The questions of whether limiting nutrients other than carbohydrates will produce the same effects and whether control of pathways is pre- or post-translational will be examined. Growth rate-fermentation product relationships may be an important feature of ecosystem activity. Studies will be continued of electron transport systems that are significant in the production of H2 by organisms whose fermentations are influenced by H2.
BIBLIOGRAPHIC REFERENCES: Chen, M. and M.J. Wolin. 1979. Effect of monensin and lasalocid-sodium on the growth of methanogenic and rumen saccharolytic bacteria. Appl. and Environ. Microbiol., in press. Wolin, M.J. 1979. The rumen fermentation: a model for microbial interactions in anaerobic ecosystems. In M. Alexander (ed.). Advances in Microbial Ecology. Vol. 3. Plenum Publishing Corp. New York, in press.
SUPPORTED BY U.S. Dept. of Health & Human Services, Public Health Service, National Inst. of Health, National Inst. of Allergy & Infectious Diseases

7.0079,

ADAPTATION OF THE SIMPLEX GASIFICATION PROCESS OF DEWATERED SEWAGE SLUDGE

T.E. Mullen, State Energy Research & Development Authority, *230 Park Ave., New York, New York* 10017 (CC36 -1B29)

OBJECTIVE: The main objectives of this project are: To demonstrate Sanoplex briquette formation using a mixture of coal, shredded solid waste and dewatered sewage sludge, and to determine the physical and caking properties of these briquettes.

APPROACH: The objectives will be accomplished using 20% solids content, dewatered sewage sludge using the facilities of Columbia University, New York.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab., Wastewater Research Div.

7.0080,

METHANE PRODUCTION FROM WASTE CARBON MONOXIDE

Unknown, Union Carbide Corp., Tarrytown Technical Center, *P.O. Box 278, Tarrytown, New York* 10591 (EM-78-C-03-2153)

SUPPORTED BY U.S. Dept. of Energy

7.0081,

NON-PETROLEUM FUELS FOR POWER UNITS USED BY AGRICULTURE

K.R. Kaufman, North Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Fargo, North Dakota* 58103 (ND01437)

OBJECTIVE: Evaluate the use of non-petroleum fuels such as ethyl alcohol, methyl alcohol and methane for internal combustion engines.

APPROACH: Tractor engines will be tested in the laboratory to determine the effects of substituting alcohol-fuel mixtures for tractor fuel. Both gasoline and diesel engines will be studied. Road tests will be made with automobiles to determine the effects of substituting gasoline-alcohol blends for gasoline. In all tests, comparisons will be made between the energy content of the alcohol-fuel blend and the fuel consumption of the engine. Next, engines will be modified and evaluated for performance and emissions while using alcohol-fuel blends.

PROGRESS: Tests were conducted to determine how alcohol performs in engines. Gasoline and diesel tractor engines and automobiles were tested. The engines were adjusted to factory specifications and all tests were run at these settings. The gasoline tractor engine was and an International Harvester 606. It was connected to a PTO dynamometer and tests were run at partial and full loads. A Ford 8000 was used for the diesel engine tests. It was also connected to a PTO dynamometer. Automobiles tested on the road were 1976 Ford Torinos with 351 cubic inch displacement V-8 engines. Tests were run to compare the benefits of using 190 proof ethanol as compared to 200 proopf ethanol in the alcohol-gasoline blends. To achieve a satisfactory mix and one that will not separate out over time it was found that the alcohol portion must be essentially pure (200 proof). Various blends of ethyl alcohol and unleaded gasoline were used in the tractor engines. As the quantity of alcohol blended with the unleaded gasoline was increased, the maximum horsepower which the engine was capable of producing decreased. In addition, the fuel efficiency measured in kw-hr/liter also decreased. Thermal efficiency remained approximately constant. Automobile tests showed that mileage measured in kilometers per liter decreased 3% while using gasohol-a blend of 90% unleaded gasoline and 10% ethanol.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Dakota

7.0082,

EMISSIONS ASSESSMENT FROM REFUSE-DERIVED FUEL COMBUSTION (BATTELLE)

J. Allen, Battelle Memorial Inst., *505 King Ave., Columbus, Ohio* 43201 (B827B-873)

OBJECTIVE: The objective of this project is to characterize the emissions from cofiring 3 types of refuse-derived fuel with coal in a fluidized bed combustion unit.

APPROACH: Fuels with CEA, Ames, Iowa and Milwaukee are being burned with an Illinois coal. A source assessment sampling system (SASS) is being used to determine criteria pollutants, trace metals, and selected organics.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

7.0083,

WASTE TO ENERGY TECHNOLOGY CONFERENCE - 1979 UPDATE

R. Smithson, Battelle Memorial Inst., *505 King Ave., Columbus, Ohio* 43201 (B827B-861)

OBJECTIVE: To provide a forum for new R & D results in the waste to energy technology industry.

APPROACH: A 3-day technical conference was held in Cincinnati April 15-16, 1980.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

7.0084,

AIR POLLUTION CONTROL TECHNOLOGY DEVELOPMENT FOR WASTE-AS-FUEL PROCESSES

G.A. Jutze, PEDCo Environmental Inc., *11499 Chester Rd., Suite 13, Cincinnati, Ohio* 45246 (B624B-403)

OBJECTIVE: The Environmental Protection Agency is initiating a study to assess techniques and devices to control air pollutants generated by the use of waste as fuel in energy recovery/generation systems.

APPROACH: PEDCo-Environmental and Midwest Research Institute intend to provide the personnel and services required to develop environmentally acceptable air pollution control systems for use in conjunction with waste-to-energy processes.

PROGRESS: A portable fabric filter has been constructed and is being tested at two waste-as-fuel sites. A portable scrubber has been tested at one site. A state-of-the-art report has been submitted by the contractor.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

7.0085,

EFFECTS OF BURNING DENSIFIED FORMS OF MUNICIPAL SOLID WASTE DERIVED FUELS IN INDUSTRIAL UTILITY AND INSTITUTIONAL STOKER BOILERS

J. Degler, Systems Research Lab. Inc., *245 N. Valley Rd., Xenia, Ohio* 45385 (C818A-S5T040)

This contract will study the environmental and engineering aspects of using d-RDF as a supplementary fuel with coal in stoker boilers. The contractor will be responsible for conducting the combustion studies, as well as determining the engineering and other technical requirements of detailed experimental runs at selected boiler(s).

Phase I of the study, i.e., experimental test burns, have been conducted in boilers near Hagerstown, Maryland. Phase II will involve additional runs and/or demo type run at another location.

PROGRESS: In combustion tests near Hagerstown, Maryland, coal was used with 1/2 inch d-RDF pellets in ratios of 1:1 and 1:2. few problems were evident with handling and feeding to the boiler. A second phase combustion test was conducted at the General Electric Plant, Erie, Pennsylvania. Approximately 2000 tons d-RDF from NCRR and Teledyne National were burned in ratios of up to 100% d-RDF. Differences were noted between materials handling and combustion of the more deteriorated NCRR pellets and the newer Teledyne pellets. Teledyne pellets were cleaner of inerts and fines. Emissions and other sample analyses and data reduction are in progress. The d-RDF concept appears to be feasible with possible exception of production costs.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab., Solid & Hazardous Waste Research Div.

7.0086,

INVESTIGATE BEST MIXING CONCEPTS FOR REFUSE - SLUDGE FOR BIOGASIFICATION PROJECT

J. Swartzbaugh, Systems Research Lab. Inc., *245 N. Valley Rd., Xenia, Ohio* 45385 (EY-76-C-05-5175)

SUPPORTED BY U.S. Dept. of Energy

7.0087,

SMALL SYSTEMS RESOURCE RECOVERY ANALYSIS

Unknown, Systems Research Lab. Inc., *245 N. Valley Rd., Xenia, Ohio* 45385 (EC-77-R-03-1478)

Candidate processes from the standpoints of technology, economics and institutional constraints for the development of 25 to 50 TPD urban waste processing systems will be identified. This project will analyze small scale processes (less than 100 TPD and preferably economic at 25 TPD) for urban waste to energy conversion. Some 45% of the total wastes generated in the U.S. originate in smaller cities. The small scale systems hold promise for processing wastes locally, thus saving transportation energy. Combustion, pyrolysis and bioconversion are candidate processes for this purpose.

SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Office of Conservation, Div. of Buildings & Community Systems

7.0088,

GAS TURBINE DEMONSTRATION OF PYROLYSIS-DERIVED FUELS

G.B. Jasas, Teledyne CAE, *1330 Laskey Rd., Toledo, Ohio* 43612 (Acct. No. 1256)

The objective of this program is to conduct engineering analysis and tests which demonstrate the feasibility of using pyrolytic oil and char as a fuel in a combustion turbine engine. A production Teledyne CAE J69 turbojet engine with a modified combustion system is to be used as the demonstration vehicle. The technical approach consists of four tasks timephased over a 20-month contractual effort and includes: analysis of pyrolytic fuel combustion, storage/handling effects on materials, and procurement of test hardware; bench and sub-component testing to define pyrolytic fuel chemical and physical properties, compatibility with flow handling equipment, and fuel injection system performance; and rig testing full scale combustor to optimize performance with pyrolytic fuel, measure emissions, and define modifications prior to engine demonstration. The results of this project will contribute to the technology required to commercialize pyrolysis-derived fuel burning in small-scale turbine applications and thereby provide a substitute fuel for premium petroleum and natural gas fuels.

SUPPORTED BY U.S. Dept. of Energy, Div. of Fossil Fuel Utilization

7.0089,

EVALUATION OF CONTROL STRATEGIES FROM FIELD DATA

I.J. Kugelman, U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab., Wastewater Research Div., Lebanon Pilot Plant, *5555 Ridge Ave., Cincinnati, Ohio* 45268 (C821B-02TE02)

OBJECTIVE: The objective of this research is to develop a dynamic model of the anaerobic digestion process. The model will include the following biological reactions: 1. Fermentation of volatile solids into butyrate, propionate, and acetate. 2. Fermentation of butyrate into acetate and methane. 3. Fermentation of propionate into acetate and methane. 4. Fermentation of acetate into methane.

APPROACH: An anaerobic digester will be operated at the Lebanon Pilot Plant on a pilot scale. The digester will be driven to failure in order to evaluate the coefficients for a mathematical model. The model will then be used to develop control strategies for the anaerobic digestion process. These control strategies will then be evaluated at the pilot plant.

PROGRESS: The pilot scale digester, data acquisition, and control system has been constructed and debugged. A larger scale digester has been constructed, debugged, and operating for 1 year. The purpose of the larger digester is to supply a stable biological culture for the pilot scale digester. The experimental procedure for measuring the biological cultures is currently being developed.

SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Municipal Environmental Research Lab.

7.0090,

ORGANIC HYDROGENATION

W.L. Hughes, Oklahoma State University, School of Engineering, Dept. of Electrical Engineering, *Engineering N., Stillwater, Oklahoma* 74074

The project is an experimental program of flash induction heating biomass in a special reaction vessel to produce methane and carbon which are clean fuels.

SUPPORTED BY Oklahoma State Government

7.0091,
INVESTIGATION OF ALCOHOL/GASOLINE BLENDS
R. Hurn, U.S. Dept. of Energy, Bartlesville Energy Research Center, *P.O. Box 1398, Bartlesville, Oklahoma* 74003 (2245)
The objectives are: (1) characterization of alcohol/gasoline blends; and (2) performance testing of alcohol/gasoline blends and straight methanol in spark-ignition internal combustion engine.
SUPPORTED BY U.S. Dept. of Energy, Div. of Transportation Energy Conservation

7.0092,
BIOMASS GENERATED FUEL USING ENGINE DISPLAY AT APPROPRIATE COMMUNITY TECHNOLOGY FAIR AND CONFERENCE
F. Nichols, Cascade High School, *Turner, Oregon* 97392
SUPPORTED BY U.S. Dept. of Energy

7.0093,
GASOHOL UTILIZATION AND TEST PROGRAM
H.D. Hurless, U.S. Dept. of Energy, Bonneville Power Admin., *1002 N.E. Holladay St., Portland, Oregon* 97208
The objectives are to conserve petroleum-based resources by using transportation fuels derived in part from domestic non-petroleum sources, to demonstrate in a visible way Bonneville's concern for conserving non-renewable resources, and to advance the state-of-the-art for gasohol utilization. Five late model sedans are using 10% to 20% methyl alcohol and 80% to 90% unleaded gasoline. Records are maintained on fuel economy, engine performance including exhaust emissions, and maintenance. The vehicles are performing well, and gasoline consumption has been reduced. Some highly accurate tests of miles per gallon will be conducted soon. Plans call for a large dispensing facility to be installed, and the program to be expanded to a substantial portion of the fleet of vehicles.
SUPPORTED BY U.S. Dept. of Energy, Bonneville Power Admin.

7.0094,
RESEARCH INITIATION - MICROBIAL METHANE FERMENTATION KINETICS FOR TOXICANT EXPOSURE
G.F. Parkin, Drexel University, School of Engineering, Dept. of Civil Engineering, *32nd & Chestnut Sts., Philadelphia, Pennsylvania* 19104 (ENG79-07993)
Anaerobic microbial processes have the potential to solve pollution control problems while generating energy in the form of methane gas. Wider application of such processes is limited by our lack of understanding of the effect of toxic substances on methane bacteria. This research project addresses this problem by generating fundamental kinetic data from laboratory experiments for use in deriving a dynamic model to describe the response of methane fermentation systems to exposure to toxicants.
Methane bacteria developed on an acetate-nutrient salt substrate are used to study the effect of toxicant concentration, acclimation, and temperature on the Monod kinetic coefficients k and Ks. Both batch and continuous-feed modes are used to generate the kinetic coefficients. Representative toxicants studied are ammonia, copper, formaldehyde, cyanide, an anionic detergent, and sulfide. The feasibility of adding general inhibition coefficient (Ki) to the basic Monod equation is explored.
SUPPORTED BY U.S. National Science Foundation, Div. of Engineering

7.0095,
ENERGY FROM MARINE BIOMASS
Unknown, General Electric Co., *3198 Chestnut St., Philadelphia, Pennsylvania* 19101 (ET-78-F-03-2165)
SUPPORTED BY U.S. Dept. of Energy

7.0096,
MARKET/EXPERIMENTAL ANALYSIS FOR DEVELOPMENT OF A DATA BASE AND A FUELS FROM BIOMASS MODEL
R.P. Stringer, Gilbert Associates Inc., Energy Research Division, *525 Lancaster Ave., P.O. Box 1498, Reading, Pennsylvania* 19603 (08-8247)
The contract emphasizes determining market demands for renewable energy forms derived from biomass or biological materials. Market sectors considered by the study include transportation, residential, chemical and allied products, and electric utilities. According to the Reading, PA, based engineering and consulting firm, the three-pronged project will involve the identification of available conversion technologies most in demand as well as analysis of their costs. A final phase includes developing a computerized data base of biomass material behavior in a variety of thermal systems. The project, to be completed by the summer of 1980, will be developed in conjunction with West Virginia University's Department of Chemical Engineering, where all thermal gravimetric analyzer (TGA) experiments will be conducted. A third partner in the project, Environmental Energy Engineering, Inc., will be responsible for all process development unit testing. The model will enable an energy planner with a seasonal and regional need to determine the most economical combinations of biomass resources and conversion processes to satisfy the fuel need.
SUPPORTED BY U.S. Dept. of Energy

7.0097,
METHYL TERTIARY ALKYL ETHERS AND HIGHER ALCOHOLS AS ALTERNATIVE MOTOR FUELS
Unknown, Sun Co. Inc., *P.O. Box 1135, Marcus Hook, Pennsylvania* 19061 (EM-78-C-04-4045)
SUPPORTED BY U.S. Dept. of Energy

7.0098,
SOLID-FUEL COMBUSTION RESEARCH FACILITY
D. Bienstock, U.S. Dept. of Energy, Pittsburgh Energy Research Center, *P.O. Box 10940, Pittsburgh, Pennsylvania* 15236 (7062)
The objective of this project is to study the handling, pulverizing, combustion, and fouling characteristics of coal-derived fuels such as solvent-refined coal (SRC), chars from various coal gasification and liquefaction processes under development, and blends of coal and various fuels such as process char, char prepared from agriculture and lumber wastes, and petroleum coke. The effects of combustion parameters such as primary and secondary air temperature, excess air, and particle size of ignition, flame stability and combustion efficiency will be investigated. A further objective is the investigation of the removal of SO2 from the flue gas via minerals such as nahcolite, trona, etc., and a baghouse filter. Handling and combustion studies of the coal-derived fuels and chars from coal gasification and liquefaction processes will be continued in an existing 500 lb/hr pulverized-fuel-fired furnace designed to simulate the performance of a commercial steam generating boiler. In addition, handling, blending, pulverizing, and combustion studies will be conducted with blends of coal and coal process char, char produced from lumber and agricultural wastes, and petroleum coke. SO2 emission control techniques that are tailored for smaller industrial and utility boilers will be studied and evaluated.
BIBLIOGRAPHIC REFERENCES: Yeh, J.T., C.R. McCann, J.J. Demeter, and D. Bienstock, Removal of Toxic Trace Elements from Coal Combustion Gas, Report of Investigation, PERC/RI-76/5, September 1976. Demeter, J.J., C.R. McCann, J.M. Ekmann, and D. Bienstock, Combustion of Char from Pyrolyzed Wood Waste, PERC/RI-77/9, July 1977.
SUPPORTED BY U.S. Dept. of Energy, Office of Fossil Energy

7.0099,
KINETICS OF ENZYME-CATALYZED PROCESSES
B.Z. Egan, U.S. Dept. of Energy, Oak Ridge National Lab., *P.O. Box X, Oak Ridge Operations Office, Oak Ridge, Tennessee* 37830 (W7405-eng-26)
Investigation of kinetics and enzyme catalysis related to hydrogen and ammonia production and energy production processes; catalytic processes for environmental control of waste effluents; hydrogen production from photooxidation; optimization of reaction rates; isolation, purification and stabilization of enzymes and substrates; kinetics of redox reactions of ferredoxin. Of particular interest are processes for producing hydrogen and ammonia. One such process involves photooxidation, using ferredoxin and hydrogenase to produce hydrogen. similar process would utilize ferredoxin and nitrogenase to produce ammonia for fuel. Kinetic data and catalyst stability information are not well defined for these potential processes. (ORNL/CF-78/111)
BIBLIOGRAPHIC REFERENCES: B.Z. Egan and D.W. Holladay, Use of Catechol Oxygenase for Determination of Catechol, Analytical Letters, 10, 213 (1977).
SUPPORTED BY U.S. Dept. of Energy, Div. of Basic Energy Sciences

7.0100,
ANFLOW
W. Pitt, U.S. Dept. of Energy, Oak Ridge National Lab., *P.O. Box X, Oak Ridge Operations Office, Oak Ridge, Tennessee* 37830 (W-7405-eng-26)
Develop a process to accelerate production of methane rich gas from unconcentrated sewage sludge and possibly reduce or eliminate sludge production from conventional secondary sewage treatment plants. This effort is to scale up, from the laboratory to the pilot scale, an ANFLOW reactor to function on sewage and to conduct research on various parameters such as skin effects, short-circuiting, etc. If successful, the process will provide improved economy of methane production from sewage plants. As a fringe benefit, the sludge disposal problem in modern plants is reduced. This effort was initiated in FY76. During FY78, a pilot plant will be operated to identify scale-up problems and confirm laboratory parameters. Additional laboratory work will be conducted to determine the effect of toxicants on the process.
SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Office of Conservation, Div. of Buildings & Community Systems

7.0101,
BIOENGINEERING RESEARCH
S.E. Shumate, U.S. Dept. of Energy, Oak Ridge National Lab., *P.O. Box X, Oak Ridge Operations Office, Oak Ridge, Tennessee* 37830 (W-7405-ENG-26)
The objective is to explore fundamental relationships in areas of biochemical engineering such as microbial and enzyme engineering, separation technology and bioprocess development for fuel production, energy conservation, resource recovery, and environmental protection. The approach is to use established chemical engineering research methods and techniques to conceive, design, and evaluate practical biochemical reactors and processes. Results include development of a new type of fluidized-bed bioreactor and processes for removal of nitrates, special hydrocarbons (e.g., phenols), and heavy metals from fuel (nuclear, coal) processing industry wastewaters.
BIBLIOGRAPHIC REFERENCES: Shumate, S.E. II, C.W. Hancher, G.W. Strandberg, and C.D. Scott, Biological Processes for Environmental Control of Effluent Streams in the Nuclear Fuel Cycle, in Waste Management and Fuel Cycles '78, University of Arizona, Tucson, 1978. Scott, C.D., C.W. Hancher, and S.E. Shumate II, A Tapered Fluidized-Bed as a Bioreactor, in Enzyme Engineering, Volume 3, Plenum Press, NY, 1978.
SUPPORTED BY U.S. Dept. of Energy, Office of Health & Environmental Research

7.0102,
CO-FIRING REFUSE-DERIVED FUEL IN A CEMENT KILN
J.R. Jones, Browning Ferris Industries Inc., *Fannin Bank Bldg., Houston, Texas* 77001 (EY-76-C-05-5150)
The project will be conducted in two separate phases. The initial phase will consist primarily of a laboratory investigation of the effects of RDF on cement quality and will include determination of potential limitations on use of RDF based on the ash contribution to the chemistry of the cement. These Phase I tasks involve generation and analysis of RDF samples, combustion of the RDF in a small incinerator to produce ash, subsequent analysis of the RDF ash, analysis of raw materials from cement plants, preliminary raw mix designs, laboratory scale burns and analysis of the resulting clinker. The bulk of this extremely important work will be performed by Portland Cement Association staff at their laboratories in Skokie, Illinois. Phase II includes upgrading an existing solid waste processing plant to allow production of RDF, development of an RDF transportation system (tractors and transfer trailers) and design and construction of a temporary, relatively low capital cost RDF receiving, storage and metering/feed system at the test plant in Houston. The second phase also involves performing a series of trial burns of roughly 72 hours duration each at the test plant, a wet process plant (raw materials are fed into the rotary kiln in a water slurry mixture). The trial burns will be performed at varying RDF substitution rates while the primary fuel (initially natural gas) is re-

duced. RDF will be used to provide 20%, 30%, and 40% of the kiln fuel requirements based on heating values. Part of this project has been subcontracted.
SUPPORTED BY U.S. Dept. of Energy

7.0103,
PROCESS EVALUATION - CHINA LAKE PYROLYSIS SYSTEM
F.L. Gladney, Dow Chemical Co., Dept. of Resources Research, *Freeport, Texas* 77541 (B624B-T7003)
This project is to evaluate the technical econmic and environmental feasibility of the concept of pyrolysis of solids toward the production of gasoline on a commercial basis, as demonstrated by the China Lake pyrolysis system.
The work will be done by a team of professional-technical people at the Texas Division of Dow Chemical U.S.A. at Freeport, Texas.
The project is being organized at this date 27 October 1977.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

7.0104,
METHANOL-FUEL EFFECTS ON SPARK IGNITION ENGINE LUBRICATION AND WEAR
E.C. Owens, Southwest Research Inst., Army Fuels Lubricants Res Lab, *8500 Culebra Rd., P.O. Drawer 28510, San Antonio, Texas* 78228
This project is to assess the impact of alcohol-containing motor fuels on conventional spark ignition engine lubrication and wear. A series of single-cylinder engine tests are being conducted to evaluate the nature and extent of any lubricant related problems. The work to date indicates that during periods of low-temperature engine operation, methanol and its combustion products, when reacted with the lubricant through blowby, increases the rate of wear of the piston rings and cylinder bore significantly during short-term testing. Evidence also indicates possible incompatibility with conventional lubricant additive packages resulting in diminished engine protection and precipitation of additive components. Plans for ongoing and future work leading to development of lubricants for use with alcohol-containing include extensive chemical analysis of engine blowby from the piston ring zone and evaluation of a series of commercial and experimental lubricant formulations.
SUPPORTED BY U.S. Dept. of Energy

7.0105,
ASSESSMENT OF OPPORTUNITIES FOR COST TO METHANOL CONVERSION FOR USE AS HIGHWAY VEHICLE FUEL
F. Parker, American Energy Research, *McLean, Virginia* 22101
SUPPORTED BY U.S. Dept. of Energy

7.0106,
MOUNT ROGERS SOLID WASTE/ENERGY RECOVERY PROGRAM (ABBREV)
Unknown, Virginia State Government, *Richmond, Virginia* (VA-6381-78-I-302-0615)
The Commonwealth of Virginia, on behalf of the Mount Rogers Planning District, is requesting Commission approval of a grant for the purpose of determining the engineering feasibility of a proposal for energy recovery from solid waste, as well as the community organization, financial advice and assistance and pre-planning for similar systems to serve other communities in the planning district.
Because of sub-surface limestone formations prevalent in the planning district, the present method of disposal through sanitary landfills has become a hazard to public health because of potential pollution of ground and surface water. During 1975, the Mount Rogers Planning District requested the Tennessee Valley Authority to do a regional analysis of the solid waste problem in the areas and recommend the best technology for jurisdictions in the planning district to use in the disposal of solid waste.
The TVA study recommends using solid waste as an energy source to produce steam. The steam will be sold to industrial and institutional clients identified in the study.
The project is part of the Commonwealth of Virginia's 1978 Development Plan and Investment Program. The project has A-95 approval. The Tennessee Valley Authority has indicated that this would be a technically and economically feasible method of disposal of solid waste and would provide the framework for developing regional solid waste energy recovery projects in the Mount Rogers Planning District.
SUPPORTED BY U.S. Appalachian Regional Commission

7.0107,
ACTIVATED CARBON ENHANCEMENT OF SLUDGE DIGESTION
G.W. Dawson, U.S. Dept. of Energy, Battelle Pacific Northwest Lab., *P.O. Box 999, Richland, Washington* 99352 (EC-76-C-06-1830)
Follow-up studies on laboratory results indicate that activated carbon enhances methane rich gas production in anaerobic sewage treatment plant digestors. Approximately 7,500 sewage treatment plants in the U.S. use anaerobic digestion. Methane gas produced by the process is frequently flared but could be recovered and utilized as a fuel to provide power for plant operation. Following up on promising laboratory results, a pilot plant was completed in FY77 to determine optimum conditions for activated carbon addition to enhance gas production and recovery. During FY78 field demonstrations of the pilot plant will be conducted. Potential future development could combine this process with a pyrolysis system producing activated carbon from the remaining sludge.
SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Office of Conservation, Div. of Buildings & Community Systems

7.0108,
THERMOCHEMICAL CONVERSION OF CELLULOSIC WASTES INTO LIQUID FUELS
T.F. Demmitt, U.S. Dept. of Energy, Battelle Pacific Northwest Lab., *P.O. Box 999, Richland, Washington* 99352
Investigate chemistry of thermochemical processes for direct conversion of cellulosic materials into liquid fuels; determination of process variables on reaction chemistry and reaction product properties; conversion of aqueous cellulose slurries (with dissolved alkali materials) to liquid fuels; variation of oil yields and properties with temperature (300 to 365 degrees C) and alkali addition; carbon monoxide addition not required to achieve liquefaction; mathematical modeling. (DOE/ER-0002)
SUPPORTED BY U.S. Dept. of Energy, Office of Energy Research

7.0109,
MATHEMATICAL MODELING DATA AND EVALUATIONS IN CONJUNCTION WITH THE METHANE CONSERVATION, PRODUCTION AND UTILIZATION
Unknown, Harris & Associates, *Laramie, Wyoming* 82070 (EW-78-X-21-2810)
SUPPORTED BY U.S. Dept. of Energy

7.0110,
APPLIED SCIENCE AND TECHNOLOGY RESEARCH - EGYPT
Unknown, Academy of Scientific Research & Technology, *101 Kasr El Eini St., Cairo, Egypt* (263-0016)
Project is aimed at improving the management of Egyptian applied research carried out through the Academy of Scientific Research, the National Research Council, and associated universities, research institutes, etc. It hopes to make scientific research significantly more responsive to a) end-users and b) national development goals.
Research Support may be tendered in such areas as plant production, animal and fisheries research, soil and water resources, the environment, petroleum and minerals, energy, industry and transportation.
Large-scale 'demonstration projects', interdisciplinary and inter-agency include food and nutrition, biogas, and dry land crops.
AID provides technical assistance, equipment, training and related assistance. The U.S. National Academy of Sciences and the National Science Foundation cooperate with AID in implementation. A high-level Egyptian-American Consultative Committee oversees the project. Planning for Phase II is underway.
SUPPORTED BY U.S. International Development Cooperation Agency, Agency for International Development

7.0111,
FEASABILITY STUDY ON GASIFICATION OF PEAT AND WOOD WITH MODERN WINKLER-TECHNIQUE AND OF COAL WITH TEXACO TECHNIQUE
A. Brandberg, Uhde Gmbh, *Dortmund, Nordrhein Westfalen, Federal Republic of Germany* (53 3561 041)
OBJECTIVE: Evaluation of technique under development (pressurized HT-Winkler and Texaco resp.) for domestic feedstocks (peat and wood) and imported coals.
APPROACH: Based on bench-scale data and experiences with brown coals process calculations for the feedstock preparation and gasification of peat and wood and gas purification is accomplished to form a basis for the process design. An alternative calculation is made for hard coals fed as coal water slurry to an oxygen blown Texaco gasifer.
INTENDED USE OF RESULTS: To assist in judging the feasibility of using developed gasification techniques in Sweden and to obtain first estimates of performance data and investment costs.
SUPPORTED BY Namnden for Energiproduktionforskning

7.0112,
STUDY OF STORAGE AND DISTRIBUTION OF BIOMASS-POWDER
A.F. Pelleus, K B Peleus & Co., *Linnegatan 34, S21614 Malmo, Sweden* (53 3065 301)
OBJECTIVE: Study of storage and distribution of biomass powder as a energy carrier in Sweden.
APPROACH: 1. Lay out of terminals with distribution capacities between 0.2 and 1.5 M. tons/year, divided upon small, medium and large units. 2. Flow scheme and gradual extension of distribution system. 3. Estimate costs for storage and for distribution by road, rail and waterways.
PROGRESS: First part. Second part includes distribution of powder in small or medium size quantities such as 0.5 to 10 cu. meters in containers and bags, as well as equipment for receiving powder positioned at consumer's site.
INTENDED USE OF RESULTS: For technical and economical valuation of biomass powder storage and distribution as a part in a biomass energy system, institutes and executives in industries.
SUPPORTED BY Namnden for Energiproduktionforskning

7.0113,
ASSESSMENT OF DEVELOPMENT POTENTIAL OF SMALL GASIFIERS FOR LOW KJ GAS
R. Collin, Kungliga Tekniske Hogskolan, Heat & Furnace Technology, *S10044 Stockholm 70, Sweden* (53 3066 141)
OBJECTIVE: A large proportion of Sweden's oil consumption could be substituted by alternative fuels such as coal, peat, wood waste, bark, shale and so on. Many existant furnaces and boilers, however, are built for the exclusive use of liquid or gaseous fuels. A more rapid conversion would be possible if such plants could be supplied with a generator for a low KJ-gas. The generator would have lower capacity, small dimensions and would possibly be so cheap that even small plants could be equipped with it. The present preliminary study aims at a detailed plan for an R & D project, leading to a gas generator, which must fulfil the following criteria: Must accept fuels of varying quality and heat value. The mean efficiency must be acceptable. The emission of polluting agents must be lower than stipulated by present and future regulations. It must be equipped with advanced control equipment. The equipment for supply of fuel and disposal of slag must have small dimensions.
APPROACH: The study contains the following parts: Assessment of existing technology by literature studies and study trips. Continued experiments with different fuel qualities in an existing fluidized bed furnace. Contacts and discussions with research teams in Sweden and abroad in order to assess the possibilties to collaboration.
PROGRESS: The experiments in the previous step, NE 3066062, has shown that combustion with high efficiency and low excess air ratio is possible in a small reactor, diameter 350 mm.
INTENDED USE OF RESULTS: The R&D plan will be used by the research team itself. The experiment results will be published. If the R&D plan is accepted, the result of the development may have an impact on Swedens's use of energy in 7 to 10 years.
SUPPORTED BY Namnden for Energiproduktionforskning

7.0114,
DEVELOPMENT OF ALKALINE FUEL CELLS
O. Lindstrom, Kungliga Tekniske Hogskolan, Chemical Technology, *S10044 Stockholm 70, Sweden* (53 3560 013)
OBJECTIVE: The project shall give data for the evaluation of the need for development in Sweden of a fuel cell power plant for hydrogen made out of preferably biomass and peat.
APPROACH: The work consists of 1. a preliminary technical and economic study of a fuel cell power plant including a modified steam/iron process for hydrogen production. 2. theoretical and experimental studies of the elimination of carbon dioxide from air. 3. construction and evaluation of a fuel cell battery. 4. further development of electrodes.
This project is an extension of earlier projects for the Natl. Swedish Board for Energy Sources Development, no. 53 3560 011 and 55 3560 012, and for the Natl. Swedish Board for Technical Development, no. STU 74-4532 and STU 75-5056.
PROGRESS: Earlier achievements of these projects are described in report no. 75-5056 and 74-4532 for the Natl. Swedish Board for Technical Development and in internal reports for the Department of Chemical Technology.
Intended use of results: The project is a part of a R&D program with an objective consisting of specification and evaluation of a fuel cell power plant for hydrogen from biomass and peat.
SUPPORTED BY Namnden for Energiproduktionforskning

7.0115,
GASIFICATION OF SWEDISH RANSTAD SHALE IN A FLUIDIZED BED REACTOR
I. Bjerle, Lunds Universitet, Chemical Centre, Dept. of Chemical Engin, *Box 740, S22007 Lund 7, Sweden* (53 3064 014)
OBJECTIVE: To study the feasibility of gasification of Swedish shales.
APPROACH: The gasification properties of Swedish Ranstad shale are studied in a fludized bed reactor. The reactor is 0.65 meters high and 0.10 meters in diameter. The impacts of gasification temperature, shale residence time and gasification medium on degree of conversion and gas quality are studied.
PROGRESS: The first project period from 02/76 - 02/77 most of the time were required for reactor design and reactor testing. In 11/76 a series of about 30 tests were carried out. From these tests the activation energy and the frequency factor for the gasification with steam were calculated. (Report of July 1, 1977.)
During the period from 03/77 - 02/78 the steam gasification was more thoroughly investigated in respect of hydrogen inhibition. The kinetic constants for carbon dioxide gasification were also investigated. During this period of time a two bed reactor for combined gasification/combustion was built and tested. The first hot tests were made at the end of the period.
During the present period the combined reactor will be tested more thoroughly. Other types of combustible matter, e.g., biomass, peat and coal, will be used.
INTENDED USE OF RESULTS: The results, if positive in technical and economic ways, will be useful for the companies involved in a total utilization of Swedish shale. They will serve as a base material for dimensioning the thermal steps in that type of plant.
The work is of basic character, which means that the results will not have a positive impact on the Swedish energy supply in the next decade.
SUPPORTED BY Namnden for Energiproduktionforskning

7.0116,
MEASUREMENT OF EMISSIONS FROM A FLUIDIZED COMBUSTER
I. Bjerle, Lunds Universitet, School of Technology, Dep.. of Chemical Engin, *Box 725, S22007 Lund 7, Sweden* (53 3066 231)
OBJECTIVE: To determine the amount of polyaromatic hydrocarbon and heavy metals, especially Mercury, in flue gas and fly ash from a fluidized bed combuster utilizing coal, waste, peat and biomass as a fuel.
APPROACH: The project is coupled to project No 33 3066 041 in which the impact of temperature and excess air on SOx and NOx emissions will be studied.
In connection with these tests the emissions of Mercury and other heavy metals and the polyaromatic hydrocarbons will be measured. The intention is to separate the flue gas and the fly ash and separately measure the amount of metals and PAH.
INTENDED USE OF RESULTS: The results can be used for minimizing the total environmental impact of a fluidized bed combuster through a better choice of combustion conditions.
SUPPORTED BY Namnden for Energiproduktionforskning

7.0117,
FUEL-FIBER PELLETS FROM DOMESTIC WASTE
W. Aarsrud, PLM Platmanufaktur Miljoteknik AB, *Box 836, S20180 Malmo, Sweden* (77-6366)
SUPPORTED BY Styrelsen for Teknisk Utveckling

7.0118,
PLANNING AND RESEARCH CONCERNING ENVIRONMENTAL IMPACTS WITHIN THE NE PROGRAMS 'BIOSYSTEMS' AND 'PEAT'
J. Nilsson, Statens Naturvardsverk, Dept. of Research, *Box 1302, S17125 Solna, Sweden* (53 3065 331)
BACKGROUND: The use of biomass and peat for energy production may come to be regulated by the kind and significance of the consequence to man and the natural environment.
OBJECTIVE: The research efforts needed to elucidate environmental impacts should be identified. The planning of research should comprise the identification of the problem, an account of the present knowledge and a proposal for the research that should be performed.
APPROACH: Scientific experts both within and outside of the Environment Protection Board will cooperate in the work. Parallel with an account of the processes of the different systems for energy production in question, every conceivable environmental impact is identified and analyzed, and the need for research is compiled and classified according to urgency. Planning should be focused on developments that are of great interest in the opinion of the Board for Energy Source Development (NE).
Reporting is done in two steps. A tentative report concerning the research work needed should be submitted to the NE by June 15, 1978, and the final report should be submitted by September 30, 1978.
INTENDED USE OF RESULTS: On the basis of the report it should be possible to assess the need for research as regards both its orientation and cost. The preliminary report should be drafted so detailed that the NE can recommend how large the grants should be for the research given top priority.
The final report should supply information on which to base the final decision as to the carrying out of research concerning environmental impacts of the use of biomass and peat for energy production.
SUPPORTED BY Namnden for Energiproduktionforskning

7.0119,
SUPERFLUIDIZED BED COMBUSTOR
L. Rorgren, Svenska Maskinverken Ab, *S17502 Jarfalla 2, Sweden* (53 3066 041)
BACKGROUND: AB Svenska Maskinverken (SMV) obtained license rights for superfluidized bed combustion from Sterile Disposal Plant Ltd, Darlington, England (SDP).
SDP has a number of existing units for incineration of a wide range of liquid, solid and gaseous wastes. There is not heat recovery in SDP's units.
OBJECTIVE: SMV is going to perform the SDP model for heat recovery. In the project is included an erection of a pilot unit size x W is equal to 1800 x 900 mm. Preventions are made for extending the length of the bed to 3000 mm. We will burn coal, heavy sulfur oils, wastes and so on. The possibility of retention of sulfur in limestone beds will be examined.
APPROACH: The pilot unit will be installed at a coal-fired power plant and connected to an existing coal-fired boiler.
By this arrangement we will be using existing coal handling equipment as well as existing boiler's water systems and boiler's flue gas system.
The assumed burning capacity of the bed is 900 kg coal/hour. The pilot unit will be erected in the beginning of 1978.
The following investigations will be performed: lay out the optimal effect of various fuels and the parameters which influence that; lay out the rate of emissions and the rate of retention due to various additives; lay out rate of heat transfer in the bed, load control and similar parameters for construction of FBC; lay out of the FBC's influence on the connected boiler.
INTENDED USE OF THE RESULTS: The optimized superfluidized bed will be introduced as commercial incinerator for new and existing boilers.
SUPPORTED BY Namnden for Energiproduktionforskning

7.0120,
BASIC RESEARCH WITHIN THE FIELD OF ENERGY FROM BIOSYSTEMS
Unknown, Swedish Natural Science Research Council, *Box 23136, S10435 Stockholm, Sweden* (77-7228)
OBJECTIVE: This is a joint project carried out by the Board for Energy Source Development, NE, the Natural Science Research Council, NFR, and the Board for Technical Development, STU. The object of the project is to support, by basic scientific research, NE's applied R and D program Biosystems. The aim is to obtain a more thorough knowledge of the following fields of research: the mechanism of the photosynthesis, nitrogen fixation, hydrogen gas production, enzyme and gene technology, and methane, acetone and butanol production.
APPROACH: The project has been organized as a special subject project or program. Within the framework of this program, research workers at the Swedish scientific institutes concerned may propose concrete research projects (subprojects) to be carried out. Funds totalling Skr 1.5 million have been set aside for the program in question. The subprojects are considered on their scientific merits by NFR who, after consulting NE and STU, allocates grants and also administers the project. The project work will be followed up by NFR through one or two symposia, in which representatives of NE and STU will also participates.
PROGRESS: NFR has awarded a total of 12 grants to subprojects within the above fields for the year 1978.
INTENDED USE OF RESULTS: The results of this project should prove useful to NE's program Biosystems. How the reporting of these results should best be done to serve this purpose will be discussed, among other things, at the symposia mentioned above.
SUPPORTED BY Styrelsen for Teknisk Utveckling

8. OTHER NONFOSSIL ENERGY SOURCES

8.0001,
WASTE HEAT UTILIZATION - GREENHOUSE ENVIRONMENTAL CONTROL
C.E. Madewell, U.S. Tennessee Valley Authority, *c/o OSWHA, Muscle Shoals, Alabama* 35660 (150049 TICNO)
The project objectives are to develop, test, and demonstrate systems to use waste heat as an alternate heat energy source for greenhouses and to transfer technology and provide technical assistance to commercial users. Technical and economic feasibilities of heating greenhouses with specially designed heat exchangers and low temperature condenser cooling water will be evaluated. Crop production in waste heat greenhouses will be demonstrated. Technical assistance to commercial users will be provided. An experimental direct contact heat exchange system using 70 degrees F water has been shown to be technically feasible in a pilot-scale greenhouse. A 25,000-sq-ft commercial-scale demonstration greenhouse has been operated at the Browns Ferry Nuclear Plant since January 1979. Two heat exchange systems using waste heat are being tested and compared to a conventional heat exchange system. The systems have performed near design expectations, and crops of tomatoes and cucumbers have been successfully grown. Horticultural engineering and economic evaluations are underway to refine the systems and to establish technical and economic feasibilities.
SUPPORTED BY U.S. Tennessee Valley Authority

8.0002,
WASTE HEAT UTILIZATION
J. Maddix, U.S. Tennessee Valley Authority, Office of Power, *T218 NFDC, Muscle Shoals, Alabama* 35660 (F827 -02)
OBJECTIVE: Evaluate temperatures of power plant discharge waste in soil pipe spacing for use of waste

water to extend crop growing seasons for both open-field and greenhouse crops. Optimize biological recycling of nutrients in livestock wastes by utilizing waste heat.
APPROACH: Determine whether water temperatures available at existing TVA power plants are sufficiently high to assure maximum crop response to heated soil. Conduct year-long study to test the effect of heat in pilot-scale photoplankton growth system.
PROGRESS: The report on the evaluation of the use of hot water to warm greenhouse soil has been submitted as has the report on the first phase of fish-phytoplankton growth capability and culture experience. The heated outdoor pilot-scale system is in operation.
SUPPORTED BY U.S. Environmental Protection Agency, Office of Research & Development, Industrial Environmental Research Lab.

8.0003,
RETROFIT OF HYDROPOWER GENERATION FACILITIES TO IRRIGATION SYSTEMS
J. Amorocho, University of California, Davis Campus, Agricultural Experiment Station, Dept. of Land Air & Water Resources, *Davis, California* 95616 (CA-D#-LKW-3695-H)
OBJECTIVE: To test structures and hydraulic machines for use in existing irrigation systems for small-scale generation of hydropower, especially at low heads. In many irrigation systems supplying water for agriculture, energy available for generation of electrical power is dissipated at drop structures and checks. When these projects were originally put into operation, the price of electricity was too low to justify the installation of generating units at these sites. However, the rapid increase in the cost of energy in the past few years has completely changed the economic picture, and in many cases it is now worthwhile to add generating facilities to existing irrigation projects at even relatively small drops on the main canals. Current technology permits efficient generation at heads of 5 to 8 more widespread utilization of this resource.
APPROACH: Hydraulic studies of scale models of canal intake structures are tested in the laboratory. Modifications to correct problem areas, such as the occurance of vortexes, and to improve hydraulic efficiency are made simply and at low cost. Hydraulic tests of new types of hydraulic machinery can be done in the laboratory at much lower cost than in full scale applications through the use of scale models.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, California

8.0004,
ENERGY CONSERVATION AND UTILIZATION IN CITRUS PROCESSING OPERATIONS
R.J. Braddock, Agricultural Research & Education Center, *P.O. Box 1088, Lake Alfred, Florida* 33850 (FLA-CS-01829)
OBJECTIVE: Develop methods to reduce energy consumption for producing concentrated citrus juices, dried pulp and molasses. Incorporate energy conservation concept into unit operations, pulp washing, limonene and peel oil recovery, peel leaching, drying, feed mill stack scrubbing to recover waste energy. Determine energy costs of fruit and product handling, storage, transportation and apply knowledge to conservation methods.
APPROACH: Conduct experiments in the laboratory and pilot plant and apply the results to actual processing plant situations. Primary concerns will be determining energy requirements for unit operations in processing and handling energy and material balance, waste heat recovery, development of new, lower energy consuming processing methods, equipment overdesign and integrate energy cost savings of unit processes with the entire system.
PROGRESS: A study of citrus feedmill drying parameters with pulp and pellets was conducted. Moisture sorption isotherms of dried citrus pulp cattle feed were obtained. Storage of dried pulp in atmospheres of different relative humidity resulted in pulp equilibrium moistures between 6 and 23%. Similar studies were conducted with pellets. Drying rate curves at 100 degrees C, 130 degrees C and 155 degrees C were obtained for feedmill press cake and showed constant drying rates between 70 and 20% moisture. A falling rate was apparent down to 3% moisture. Data was obtained for particle size distribution of press cake, fines and dried pulp. As an alternate to using steam evaporators for concentrating citrus industry liquids, a less energy consuming process, reverse osmosis, is being studied. An experimental laboratory scale reverse osmosis unit has been contructed and is currently being put into operation. The heats of combustion of dried citrus pulp have been found to be 4150 plus or minus 118 cal/g or 7470 plus or minus 214 btu/lb. D-limonene and dried citrus pulp have been compared with bunker 'C' fuel as a source of energy. These data indicate that D-limonene and dried citrus products are more valuable as a commodity than as a source of fuel. A data acquisition system using a minicomputer was developed to monitor and control a pilot plant citrus evaporator. Juice feed, solids (Brix), steam flow, temperature, and vacuum were measured to formulate a heat and mass relationship for the multiple effect unit.
SUPPORTED BY Florida State Government

8.0005,
IMPROVED ENGINEERING TECHNOLOGY FOR PRODUCING POULTRY AND POULTRY PRODUCTS TO CONSERVE ENERGY
W.K. Whitehead, U.S. Dept. of Agriculture, R.B. Russell Agricultural Research Center, *P.O. Box 5677, Athens, Georgia* 30604 (7902-20531-002)
OBJECTIVE: Increase poultry industry efficiency through improved or modified processes and equipment to more effectively use, reuse and recover energy.
APPROACH: Reduce energy requirements and costs for various phases and processes of poultry production and processing facilities by developing economical energy recovery and reuse systems and alternate energy soruces such as solar and biomass. The efficiency of current operating processes, including heating, cooling, refrigeration, pollution control, materials handling and transportation will be determined and more economical energy saving techniques will be applied.
PROGRESS: A pilot-scale activated sludge waste treatment system was operated at a commercial poultry processing plant for the entire year. It removed 50% of the BOD(5) in the wastewater at hydraylic detentions as short as 1 hour. The nonsteady flow operation of the system prevented higher operating efficiencies but the process was capable of treating this type of intermittent flow. Pilot-scale sand filters were installed at a processing plant's lagoons to treat the lagoon effluent. Wastewater is applied to the filter beds daily at rates ranging from 0.23 to 1.4 m /m /day and operating efficiency determined by analyzing the influent and effluent. A sand filter operated at these loading rates may be capable of operating for 9-12 months without cleaning. A stainless steel heat exchanger with 5 plates was used to recover heat from discharged scalder water. Both series and parallel flow arrangements were tested with the parallel arrangement recovering more heat. Heat recovery is accomplished without screening or filtering the water and without the use of other energy requirements such as pumps. An energy survey of three selected poultry processing plants was conducted to determine electricity and fuel uses in the various processing areas. Results of the survey show high electrical use for refrigeration and waste disposal. Annual electricity, natural gas and fuel oil consumption per pound of shipped product were determined.
SUPPORTED BY U.S. Dept. of Agriculture, Agricultural Research, Athens Georgia Area

8.0006,
INTENSIVE AQUACULTURE USING THERMAL WASTE WATER
Unknown, Astro Marine, *Eleele, Hawaii* 96705
SUPPORTED BY U.S. Dept. of Energy

8.0007,
TIME AND ENERGY REDUCTIONS FOR FIELD MACHINE OPERATIONS
D.R. Hunt, University of Illinois, Urbana Champaign Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Urbana, Illinois* 61801 (ILLU-10-0334)
OBJECTIVE: Evaluate a proposal for using the waste heat from a combine engine to preheat harvested grain destined for a dryer.
APPROACH: Make a mathematical model of the process and determine the optimum design parameters for heat transfer to the gain. Design and construct a heat exchange apparatus which will use the heat from a typical conbine engine to raise the temperature of the grain in the tank. Test the concept and the design with field studies.
PROGRESS: A procedure has been developed for determining the optimum amount of expenditure for land forming where row crop culture is used on sloping lands. Mathematical models of the costs of terrace construction, soil erosion, and machine operation have been completed and are used in a FORTRAN computer program to aid an experienced engineer in designing a terrace system that optimizes the use of such crop land. Optimization is obtained with directed procedures after the location of a terrace system is proposed. The computer program designs a balanced cut-and-fill terrace within specified constraints, automatically considers alternative designs, and prints an economic evaluation of the proposal. The engineer is thus guided to new and better system proposals. The Universal Soil Loss Equation is used to model soil loss from the individual fields created by the terrace systems. Parallel broadbase and grassed back-slope terraces with both underground tile and grassed waterway outlets are design options. Scraper and farm equipment travel are modeled to enable the prediction of terrace construction costs and the costs of farming irregular fields. Soil erosion costs are determined from calculated sediment delivery and deposition removal costs. The program was tested with typical data and the results compared favorably with actual activities and costs.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Illinois

8.0008,
SURFACE HEATING GREENHOUSES WITH WASTE HEATED WATER
P.N. Walker, University of Illinois, Urbana Champaign Campus, School of Engineering, Dept. of Agricultural Engineering, *106 Engineering Hall, Urbana, Illinois* 61801
This project will help determine the feasibility of heating greenhouses with waste heated water produced at the Baldwin Power Plant. A commercial-type greenhouse has been constructed next to the power plant cooling lake. Water is being pumped from the power plant discharge canal to the greenhouse where it is distributed over the outside surface of the greenhouse. This technique is called surface-heating and allows the use of much cooler water than could be used with conventional heat exchangers. Note that this heating system does not supply all of the energy required to heat a greenhouse. It does, however, significantly reduce the heat required from conventional sources. The surface heating system will be supplemented with a conventional heating system to maintain a constant 68 degrees F.
The energy and economic efficiency of the system will be measured by operating the surface heating system only every other day. On the other days the greenhouse would be heated using the conventional heating system alone. By comparing the energy use with and without the waste water heating system the energy savings will be demonstrated.
SUPPORTED BY U.S. Dept. of Energy

8.0009,
CONTROL OF DUST, HUMIDITY AND VENTILATION IN CONFINEMENT LIVESTOCK BUILDINGS
D.S. Bundy, Iowa State University of Science & Technology, Iowa Agricultural & Home Economics Experiment Station, Dept. of Agricultural Engineering, *Beardshear Hall, Ames, Iowa* 50010 (IOW02329)
OBJECTIVE: Develop feasible methods of removing dust from an animal confinement building. Find feasible methods of condensing moisture from the air and recapturing the latent heat in the form of sensible heat to reheat the building. Incorporate these methods in a new design scheme for animal confinement buildings, revamping the ventilation design for optimum control of dust and high humidity. Design controls for ventilation fans and air distribution systems to utilize minimum air flows.
APPROACH: Systems components will be designed and tested in a laboratory prior to being used in a swine confinement building. The dust control system will utilize particle charging by a corona discharge. The moisture removal system will use a heat exchanger. The ventilation control system will use a logic circuit for operating fans and air distribution system.
PROGRESS: In well managed swine farrowing and nursery buildings, the minimum winter ventilation rates are less than can be practically achieved by the fans, distribution, and control system. A microprocessor is being utilized to interface with input sensing elements and output signals to ventilation components to control the environment of livestock buildings. The inputs include outside temperature, inside temperature, and inside dew-point sensing. The outputs are signals to variable-speed fans, single-speed fans, heaters, and baffles motors. A dew-point sensor is presently being tested as an input device to the microprocessor. The micro-

processor eliminates the use of multiple independent controls for fans and heaters. Moisture production in farrowing units is also being studied. The studies show that existing data over-estimates moisture production in modern farrowing systems. A computer simulation study is presently being developed to project minimum ventilation rates for a wide range of temperatures using the moisture data from this study.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Iowa

8.0010,
MATERIALS SUPPORT TECHNOLOGY: CATALYSTS FOR THE REACTION OF CARBON DIOXIDE AND HYDROGEN
K. Nicholas, Boston College, Chestnut Hill Campus, School of Arts & Sciences, Dept. of Chemistry, *140 Commonwealth, Chestnut Hill, Massachusetts* 02167 (N00014-78-C-0558)
The overall objective of this task is to provide alternative approaches for the conversion of carbon dioxide and hydrogen to organic compounds such as methyl alcohol. Results from this work will provide new approaches to dealing with gases which are produced aboard submarines. In addition, this research is relevant to the Navy's interest in synthetic fuels.
Transition metal catalysts for the conversion of carbon dioxide and hydrogen to organic compounds will be developed. This research will include the preparation and characterization of transition metal-carbon dioxide complexes and the examination of the reactions of these complexes with molecular hydrogen.
SUPPORTED BY U.S. Dept. of Defense, Navy, Office of Naval Research

8.0011,
RESEARCH ON THE DEVELOPMENT AND COMMERCIAL EXPLOITATION OF TIDAL ENERGY
Unknown, Northeastern University, School of Engineering, Dept. of Mechanical Engineering, *360 Huntington Ave., Boston, Massachusetts* 02115
SUPPORTED BY U.S. Dept. of Energy, Office of Energy Research

8.0012,
LOW GRADE WASTE HEAT UTILIZATION (TMP044)
T. McFadden, U.S. Dept. of Defense, Army, Corps of Engineers, Cold Regions Research & Engineering Lab., *P.O. Box 282, Hanover, New Hampshire* 03755 (DA0G0867)
The assumption has been that low grade waste heat (70-80 degrees F) can not be cost-effectively utilized.
The approach was to analyze and to field test an actual attempt to utilize low grade waste heat. An experiment was designed to evaluate heat transfer characteristics of soil and develop techniques to enhance transfer of heat to soil layers. The experiment was conducted at Ft. Wainwright, Alaska in cooperation with the University of Alaska. The objective was to determine if agricultural crop growth could be sufficiently enhanced by low grade waste heat to be cost effective.
SUPPORTED BY U.S. Dept. of Defense, Army, Corps of Engineers, Cold Regions Research & Engineering Lab.

8.0013,
UTILIZATION OF WASTE HEAT FROM POWER PLANTS IN AQUACULTURE
C.R. Guerra, Public Service Electric & Gas Co., *80 Park Pl., Newark, New Jersey* 07101 (ENV76-19854 A03)
This is an award for completion of the prior fiscal year funding of the final two years of this planned three-year experiment. The objective is to determine the technical and economic feasibility of utilizing heat remaining in condensor cooling water at power generating stations for culturing of edible aquatic animals. The aquaculture research facility located at the Public Service Electric and Gas Company's Mercer Generating Station at Trenton, New Jersey is being used for the sequential culture of freshwater shrimp from May through October and rainbow trout from November through April. The experiments are being conducted at a sufficiently large scale for determination of reliability and reproducibility of the concept and acceptability of the products. A subcontract to Rutgers University for research directed by A. Farmanfarmaian is concerned with studies of nutritional factors including amino acids and calcium diet supplementation, food conversion efficiencies and physical factors influencing intestinal absorption of food and potential pollutants such as coal, chlorine and heavy metals. A subcontract to Trenton State College in supporting research under the direction of A.F. Eble to improve the aquaculture procedures being used at the Trenton site. This includes field application of nutritional data, intensification of culture techniques and brood stock management. Long Island Oyster Farms, Inc. is assisting in evaluation of commercial feasibility and the New Jersey Department of Agriculture's Division of Rural Resources in studying adaptation of conventional agricultural facilities to production of fingerling trout. A project workshop will be conducted on March 29-31, 1978 at Rutgers University. This action completes the FY 78 funding of award ENV 76-19854.
SUPPORTED BY U.S. National Science Foundation, Div. of Advanced Environmental Research & Technology

8.0014,
WASTE HEAT GREENHOUSE
D.M. Stipanuk, Cornell University, Ithaca Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *Ithaca, New York* 14850 (NYC-123347)
OBJECTIVE: Evaluate the technical and economic feasibility of heating a greenhouse in New York State with waste heat from an electrical generating station.
APPROACH: A greenhouse will be erected on the Cornell Campus. Simulated power plant cooling water will be run through a heat pump to extract heat. This heat will be transferred to water filled plastic bags in the greenhouse. These bags will serve as heat exchangers. Work will be conducted to determine the ability of plants to integrate temperature. The effect on plant growth and yield of varying temperature will be assessed.
SUPPORTED BY New York State Government

8.0015,
ENGINEERING ANALYSES OF ENERGY STORAGE FOR AGRICULTURAL USES
H.M. Keener, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00613)
OBJECTIVE: Evaluate known or synthesize systems for collection and storage of solar, waste, electrical or bioprocess heat for their applicability to conserve fossil fuels in agricultural systems.
APPROACH: Determine the functional characteristics of heat-dependent agricultural processes which may be amenable to substitution for fossil fuel heat. Determine the operating characteristics of candidate heat collection and storage devices. Determine, by systems analysis, the optimum match between collection/acquisition rate and heat storage capacity for each of the heat dependent processes, based upon criteria of fuel availability, space, or cost, etc. Specify and publish example systems which are feasible solutions to meeting heat requirements of agricultural process systems.
PROGRESS: Heat storage tank shapes analyzed for surface area to volume ratios. Results suggest that for an open top structure, a cylindrical storage structure with radius equal to height and a hemispherical bottom would have the minimum surface to volume ratio. In an isothermal environment, this structure would minimize heat loss during heat storage. Studies on the non-isothermal environment are underway. Experimentation on the heat collection and storage with a solar pond 8.5 x 18.3 x 3 meters continued. The maximum temperature reached during 1978 was 57.0 degrees C and represents a heat storage of 62x109J. Heat extraction equipment has been tested for heating of a greenhouse. Simulation of a high temperature collector (Owens-Illinois SunPak) coupled to a large storage system for use in providing heat for 10,000 bushel grain drying system started. Collector area versus tank sizes studied for years 1970-1977 at Wooster, O. This collector-storage system would cost over 18 times more than current electric/gas drying systems. Cost curves showing allowable cost of heat storage for grain drying developed. Simulation of animal heat recovery systems and high temperature solar collectors coupled to storage for use in providing heat for process dairy water (on the farm) continued. Experimental equipment procured and installation begun for field study of a total heat system for a 100-200 cow dairy herd. Field experimentation results showed water at 38-40 degrees C returning from heat recuperator.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Ohio

8.0016,
UNUSED THERMAL ENERGY FROM ELECTRIC POWER GENERATION - TECHNICAL FEASIBILITY
W.L. Roller, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00210-SS)
OBJECTIVE: Study modes of heat transfer for evidence of applicability to the dissipation of heat energy from lukewarm water to agricultural processes. Analytically synthesize combinations of modes into systems which may be evaluated by computer models. Develop pilot model hardware of the system that looks promising in the computer models and test performance experimentally. Make a computer analysis of the economic applicability of the pilot model(s) to the agricultural processes for which suitability appears probable.
APPROACH: Assemble a team of production environment specialists, heat transfer specialist and computer simulation specialists and proceed to attack the problem as indicated in the objectives. Procedure will be updated as facts become available.
PROGRESS: The possible use of power plant waste heat for soil heating in greenhouses is being examined. The first year of this EPRI-sponsored study was completed during the 1978 and served to characterize the physical properties of heat and moisture flow in a diverse set of soils - silt-loam, peat-vermiculite and sand. The heating system being studied consists of 0.025 m pipes, buried in each soil plot at a depth of 0.3 m and spaced 0.3 m apart, that carried heating water at regulated temperatures of 25, 30, 35 and 40 degress C. The irrigation system maintained a water table at a constant depth of 0.5 m. It was determined that sand and silt-loam are approximately equivalent heat conductors and can, for the conditions and heating levels studied, transfer between 19 and 38 watts/m of thermal energy to the greenhouse air. This represents 9 to 18% of the maximum aerial heating load observed for this greenhouse and up to 30% of the average annual load. The peat-vermiculite figures are, in each case, approximately half of these levels. Some decrease in soil moisture content was observed at the higher heating levels in the region of the heating pipes in the silt-loam and peat-vermiculite soils, but this decrease was not sufficient to pose plant growth problems. Average root-zone soil temperatures ranged between 17 and 32 degrees C. In the second year of the study, the growth of lettuce (variety HR-5) in the heated soil is being studied.
SUPPORTED BY Ohio State Government

8.0017,
ALTERNATIVE ENERGY HEATING OF DAIRY PROCESS WATER
W.L. Roller, Ohio Agricultural Research & Development Center, *Wooster, Ohio* 44691 (OHO00274-SS)
OBJECTIVE: Determine, demonstrate and disseminate factual information on the management of alternative energies (such as animal heat in the milk, solar heat collected and offpeak electric energy) to decrease the demand for fossil fuel energy in the heating of Process Water on Ohio's Dairy farms.
APPROACH: An operating dairy production facility is available as part of the new OARDC Dairy Research Center. Alternative energy conservation system interactions have been modeled on the computer using design parameters as used by the Dairy Research Center architect for heating and storage capacities and process requirements. The simulation-optimum system of animal heat recovery, solar heat collection and off-peak electric heat make-up will be demonstrated by retrofitting to the facilities now nearing completion. All solar collectors used will be commercially available units as is the animal heat recovery and off-peak electric heating will be made. Factual information on energy savings will be disseminated via on-site field days and through the written, oral and visual media.
PROGRESS: Several computer simulations were run to find the best combination, connection and management strategy for the use of in-line milk coolers, bulk-tank cooler condenser heat recuperators, solar water heaters and electric off-peak heaters in the heating of process water for dairy production units. Commerical equipment has been selected, matched and installed (with the exception of the solar collectors) in production unit of the OARDC Dairy Research Center. A new generation of evacuated-tube, glass-tube, water-heating collectors is scheduled for installation in March 1979. Simulation suggests that about 60-65% of the process heating needs will be met by the recovery of heat from the milk cooling system, about 30-35% will come from the solar collectors and the last 5-10% will come from off-peak

electrical resistance heat. In the short time in December that the system, less the solar collectors, was in operation, the temperature of water heated by heat recovered from this milk cooling system tended to verify this estimate. Since this project is basically a grant-funded energy conservation demonstration, considerable effort has been expended to cluster, arrange and display the essential elements of the process water heating system and the performance data collection. (Text Truncated - Exceeds Capacity)
SUPPORTED BY Ohio State Government

8.0018,
ENERGY RECOVERY FROM DAIRY SYSTEMS
H.D. Bartlett, Pennsylvania State University, University Park Campus, Agricultural Expenment Station, Dept. of Agricultural Engineering, *201 Shields Bldg., University Park, Pennsylvania* 16802 (PEN02334)
OBJECTIVE: Develop and evaluate systems for recovering heat from dairy barn ventilation and milking systems.
APPROACH: A heat recovery system using 'heat pump' principles will be developed for capturing surfaces will be employed to absorb heat from the ventilation by cooling the air and condensing moisture; captured heat will be transferred through water cooled condensers to a hot water storage tank. Evaporator design will incorporate means to minimize dust fowling and/or to simplify procedures for removing dust accumulation. Following development of operational systems, heat transfer coefficients, net energy recovery and capital costs will be determined. In addition, heat recovery by the use of newly developed watercooled condensers for milk cooling equipment will be evaluated in relation to energy saving.
PROGRESS: The heat pump system for recovering heat from dairy housing facilities has been designed and equipment selection has been completed. Upon delivery of all equipment components, the installation of the prototype system in one of the university barns will be completed and placed in operation to test operational performance in relation to heat recovery potential. Instruments for measuring thermal parameters in a milk cooling heat recovery system have just been received and will be installed for obtaining data on the heat recovery capacity of such equipment. f as low as 8 in/second; e.g. S. vittatum larvae and pupae were found covering the submergent vegetation in a small trickle through a cow pasture behind Route 45 sewage treatment plant. The heaviest infestation of S. venustum was found in Galbraith Gap Run behind Skimont with a density of about 300 per sq. m. during June and July. All Poconos sites had high densities, the larvae often forming extensive mats on the rocks. There were no more than two species simultaneously found in each collecting site with exception of Snow Chanty Run which maintained three species syntopically. Galbraith Gap Run supported four species over a seven month period. A Colbo-type rearing facility is being built for laboratory reaning of black flies.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Pennsylvania

8.0019,
INTENSIVE CATFISH CULTURE AND ITS EFFECT ON A THERMALLY MODIFIED RESERVOIR
R.L. Noble, Texas A & M University, College Station Campus, Agricultural Expenment Station, Dept. of Wildlife & Fisheries Sciences, *College Station, Texas* 77843 (TEX01896-R)
OBJECTIVE: Determine optimal production procedures for raising channel catfish in heated water discharge of an electric power plant. Investigate requirements for obtaining one-year generations of catfish with improved growth rates and better feed conversions. Determine the effect of an intensive fish culture operation on the growth, distribution and abundance of native fishes in a thermally heated reservoir.
APPROACH: Catfish will be reared in m cages located in the discharge waters of a power plant during the winter months and in the intake canal during the summer months. Production levels will be increased annually for several years and changes will be noted in the native fish population. Water quality and population studies will be concurrently conducted along with the culture experiment. The catfish reared in cages will also be used in a genetic experiment to improve growth rate, feed conversion, and generation time through selective breeding.
SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, Texas

8.0020,
EFFECTS ON SELECTED ORGANISMS OF WATER PASSING THROUGH THE CEDAR BAYOU GENERATING STATION.
K. Strawn, Texas A & M University, College Station Campus, Agricultural Experiment Station, Dept. of Wildlife & Fisheries Sciences, *College Station, Texas* 77843 (TEX01869)
OBJECTIVE: Determine the suitability of electric power plant cooling water for growth, food conversion, and survival of selected species of crustaceans and fishes in cages, ponds, and temperature-controlled tanks.
APPROACH: Animals will be held in cages in front of the plant intake and in the discharge canal; in fish ponds located near the start of the discharge canal; and in aquaria in a laboratory to be built near the fish ponds. After the construction of the cooling pond, animals will be kept in cages in its first and last compartments and occurrence and distribution of selected organisms in the cooling pond will be determined. Temperatures in the aquaria will span the range of temperatures usually occurring in Trinity Bay. The influence of the effluent on phytoplankters both in the field and in culture will also be determined.
PROGRESS: Information on the relationships between organisms and power plants is needed to permit efficient generation of electricity and protection of the environment. The use of waste heat and pumped water at power plants for the culture of shrimp and fishes is not fully understood. Survival of crustaceans and fishes taken from the intake screens of the P. H. Robinson Generating Station on Galveston Bay, and placed in cages for a week in the intake canal was lower than that of the same species collected by other means. Fish numbers were low during hot weather both afferent and efferent of the cooling towers on the discharge canal. Evidently fish died in the hot afferent of the cooling towers and did not survive to stock the cooler water downstream. Growth rates of several fishes cultured at various temperatures in cages placed in the cooling lake of the Cedar Bayou Generating Station and in a greenhouse laboratory were determined. Growth of brown shrimp increased with an increase in softness of the pond bottom. Fertilization with urea increased the growth rate of white shrimp in 0.1 heatare flow-through ponds. Shrimp concentrated at the inlet and discharge ends of these ponds and were most abundant at the down wind end. A chance experiment indicated that stocking postlarval shrimp at intervals might give better production than stocking all at once. Polyculture of fish and shrimp produced greater growth in fishes than monoculture. Individuals in polyculture ate more food than the same individuals in monoculture.
SUPPORTED BY Texas State Government

8.0021,
SALINITY POWER FROM ELECTROCHEMICAL CONCENTRATION CELL
A.T. Emren, Goteborgs Universitet, Dept. of Physical Chemistry, *411 Vasaparken, S40010 Goteborg, Sweden* (53 5565 031)
OBJECTIVE: Theoretically the fresh and brackish water that enter the sea at or near the Swedish west coast can give about 10 GW. The purpose of this project is to find an economically usable method to extract some part of the energy.
APPROACH: The most promising methods of energy production from salinity diffrences are electrochemical concentration cells, mechanochemical energies and pressure retarded osmos. The electrochemical method is the most direct one and in the present part of the project, the main part of the work will be done on this method.
PROGRESS: A small stack with an output power of 2mW has been constructed and tested during about three months. It suffered from great leakage of water between salt and fresh water compartments. The output voltage was 0.5 - 1.1 V. Fouling with microorganisms made it necessary to terminate the tests after about three months of operation. The stack is described in a report in May 1977. The first part of the project will be elimination of the water leakage. When a small stack has been constructed, which has properties within 20% from the calculated, a bigger stack with an output power of about 5 W will be constructed. There are fouling problems in connection with all the methods mentioned, and thus one part of the project is studies of this difficulty. Another and minor part is a theoretical study concerning the thermodynamics of mechanochemical engines for energy production from salinity differences. A group of scientists from different disciplines has studied the properties of a hypothetical 200 MW power plant. The estimated energy price is 3.5 - c/kWh. These results are described in the report 'Saltenergi i Sverige'.
INTENDED USE OF RESULTS: The major part of the salinity power will probably be produced by big companies for power production. At certain places, however, there are perhaps possibilities of small plants giving 20 - 100 kW. The first commercial plants cannot be expected to occur earlier than 1990.
SUPPORTED BY Namnden for Energiproduktionforskning

8.0022,
MICROBIAL FOULING OF ION-EXCHANGE MEMBRANES IN SEA WATER AND FRESH WATER (SUBPROJECT UNDER 'ENERGY FROM SALT GRADIENTS')
K.R. Gundersen, Goteborgs Universitet, Marine Microbiology, *411 Vasaparken, S40010 Goteborg, Sweden* (53 5565 061)
OBJECTIVE: To investigate the formation of 'primary films' and microbial fouling of various ion exchange membranes in streaming sea water and fresh river water as a function of depth, flow rate, seasonal temperature and other chemical and biological parameters. Determination of effect of fouling on flow of ions. Methods of prevention of reduction of fouling.
APPROACH: Membranes are packed in cells and mounted in chamber through which test water will be continously pumped directly from the sea (1 and 40 m depth) or from the Cota River. Membranes will be removed with short and longer intervals for chemical and microbiological analysis.
INTENDED USE OF RESULTS: If fouling is not found to interfere seriously with the flow of ions through membranes or fouling can be prevented by reasonable means the main project, 'Energy from salt gradients' may become a feasible method of producing electrical power.
SUPPORTED BY Namnden for Energiproduktionforskning

8.0023,
ENERGY PRODUCTION BY PRESSURE RETARDED OSMOSIS
R. Wimmerstedt, Lunds Universitet, School of Technology, Dept. of Chemical Engin, *Box 725, S22007 Lund 7, Sweden* (53 5565 041)
Energy differences between water at different salt concentration, for instance between river and sea water may be used for electrical energy production.
One method for this is based on utilizing the difference in osmotic pressure between the liquids in a membrane process, pressure retarded osmosis. Thereby the river water diffuses through the membrane against a hydraulic pressure gradient and is then expanded in a turbomachine.
The aim of the project is a technical-economic evaluation of the method for commercial energy production.
The investigation is based on experiences from full membrane processes for scale water desalination. A cost estimate is made for a power plant on 200 MW situated at the entrance of Nordre Alv, Sweden.
The results are expected to be a base for decisions regarding further work on pressure retarded osmosis.
SUPPORTED BY Namnden for Energiproduktionforskning

9. MULTIPLE ENERGY SOURCES

9.0001,
ALASKA STATE CAPITOL PLANNING
W. McConkey, State Dept. of Commerce & Dev., *Juneau, Alaska* 99801 (EY-76-C-06-2332)
The main purpose of this program is to provide an energy planning group to promote adoption of recommended energy conservation technologies into the planning and design concepts and to further evaluate district heating, waste conversion and alternate energy sources, such as geothermal, solar and wind and their incorporation in Alaska's new State Capital. The objective of the current Phase II work being conducted is to influence the capital planning process to insure that energy conservation design is incorporated into the construction of the new Community. The scope of the proposed project is limited to energy conservation, restricting the groups func-

tions to the implementation of proven technologies and, to the extent possible, allow for the timely incorporation of developing technologies as they become proven.
SUPPORTED BY U.S. Dept. of Energy, Office of Conservation & Renewable Energy, Office of Conservation, Div. of Buildings & Community Systems

9.0002,
ETHANOL PRODUCTION FOR AUTOMOTIVE FUEL USAGE: ENGINEERING AND ECONOMIC STUDIES FOR DIRECT APPLICATION OF GEOTHERMAL ENERGY
J. Yu, Bechtel National Inc., Dept. of Research & Engineering, *50 Beale St., P.O. Box 3965, San Francisco, California* 94119 (13412)
This project is a technical and economic feasibility study of ethanol production from farm products such as potatoes, wheat, and sugar beets using geothermal resources in the Raft River region of Idaho. The study examines feedstock availability, processing requirements, and geothermal resources resulting in a conceptual design of an alcohol facility with an integrated geothermal brine collection use and reinjection system. Capital and operating costs of the facility prepared from this study are used for the economic analysis of such an alcohol venture in the Raft River region.
SUPPORTED BY U.S. Dept. of Energy, Office of Resource Applications, Office of Industrial & Utility Appl. & Oper., Div. of Geothermal Energy

9.0003,
ENERGY IN WESTERN AGRICULTURE--REQUIREMENTS, ADJUSTMENTS, AND ALTERNATIVES
W.J. Chancellor, University of California, Davis Campus, School of Engineering, Dept. of Agricultural Engineering, *Davis, California* 95616 (0067605)
Objectives are to estimate current patterns and amounts of energy inputs currently utilized in Western agriculture. Assess contributions of, and prospects for, alternative technologies and policies for dealing with changes in energy availability. Field and interview investigations of details of energy use for inputs, production, transport, processing and distribution of key agricultural commodities. Investigation of energy use for alternative technologies at each of the above stages. Studies on detailed energy requirements for wheat production were completed and similar studies for sugar beet production and processing instituted. Sugar beets in California require more energy annually than any other single crop. The major requirement is in the processing of the beets. The 23 percent of the process energy required for drying (2 percent of California's agricultural energy requirement) represents a potential area for substitution of renewable energy sources (such as solar or crop residues) for natural gas--currently the main energy source for sugarbeet processing and fertilizer production. Studies on the feasibility of a month-by-month monitoring and requirement projecting system for California's agricultural energy flows is currently underway.
SUPPORTED BY U.S. Dept. of Energy

9.0004,
ALTERNATE ENERGY SOURCES FOR AGRICULTURAL APPLICATIONS
R.W. Hansen, Colorado State University, School of Agricultural Sciences, Dept. of Agricultural Engineering, *Fort Collins, Colorado* 80523 (COL00064)
OBJECTIVE: Investigate alternate energy sources for agricultural applications. Develop and test a multiple-use solar heat collection, storage and application system for agricultural uses. Investigate applications of wind energy for agricultural energy needs. Investigate potential fuel production from agricultural waste material.
APPROACH: This project will investigate the possible applications of solar energy to grain drying, livestock building space heating, water heating for dairy use and similar applications. Wind energy will be investigated for potential agricultural applications. Organic waste materials will be investigated as a material for the biological production of fuel gases such as methane, utilizing new techniques to produce bio-gas.
PROGRESS: Efforts for this reporting period centered around anaerobic fermentation of the fibrous fraction of feedlot waste. This process yields both a methane-rich gas and a protein-rich solid residue. The gas is directly usable as a fuel, and the residue can partially replace soybean meal and other feed supplements, thereby sparing the fuel ordinarily consumed in their production. In one set of experiments, raw feedlot waste fibers were fermented at 50 degrees C and neutral pH for 12 days. This resulted in the production of about 210 liters of gas (roughly 60% methane) per kilogram of fiber. Crude and true protein levels in the final residue were 13% and 25%, respectively, nearly double the amounts in the unfermented fibers. In other experiments, fibers, pretreated with steam at 130-210 degrees C were fermented in a similar manner. This resulted in considerably greater increases in protein (up to 65-70% more than above) but lower yields of methane. Protein production increased and gas production decreased with the severity of the steam treatment. Evidently, caramelization products were formed that inhibited the methanogenic but not the acidogenic bacteria. Future studies will attempt to determine the process parameters that result in the maximum fossil fuel advantage.
SUPPORTED BY Colorado State Government

9.0005,
ECONOMIC IMPACTS OF ENERGY DEVELOPMENT AND USE ON AGRICULTURE AND NATURAL RESOURCES
J. Barse, U.S. Dept. of Agriculture, Economics & Statistics Service, Economic Development Div., *14th & Independence Ave. S.W., Washington, District of Columbia* 20250 (NRE-43-309-11-00)
OBJECTIVE: Analyze supply and demand factors that will influence the potential for fuel wood and home heating. Analyze the economic feasibility of energy (biomass) crops, including land and water requirements, impacts on traditional crop production and environmental implications. Assess the economic implications of alternative coal and oil shale development and associated activities on environmental quality and the competition for resources in rural areas.
APPROACH: Assess the economic resource use and environmental implications of public programs to encourage 'energy farms.' Develop regional reports on current land and water use, the economic implication for future resource use, resource competition, and environmental quality resulting from alternative levels of coal and oil shale development, and related activities. Develop an interregional linear program to evaluate conflicting reclamation budgets from available literature, cooperation with other agencies within and without USDA, and limited empirical studies. Budgeting techniques and linear programming will be used to estimate water demand for energy development and to appraise the economic and environmental implications of alternative water supplies.
SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Natural Resource Economics Div.

9.0006,
ENERGY ANALYSIS OF MODELS OF THE UNITED STATES
H.T. Odum, State University System of Florida, University of Florida, School of Engineering, Dept. of Environmental Engineering Sciences, *220 Black Hall, Gainesville, Florida* 32611 (6608)
This is a renewal proposal to continue developing and evaluating an analysis model of the United States including energy sources, sectors of the economy and environmental interaction. Included in this year's objectives are transportation alternatives, potentials of a wood economy, air conditioning, shaft-mined coal, health care, air pollution, energy analysis of disasters of earthquake, hurricane, tornado, etc., the simulation of a state energy model (Florida), the calculation of energy quality of natural gas, peat, wood, soil, land, and other main components of the U.S. systems. The methods we use differ in several ways from those used by others. A special effort will be made to review reports and publications on net energy and energy analysis by other groups making energy analysis diagrams with their data for comparing, locating and showing what differences there are in what is included and how these differences make conclusions different. Energy quality evaluations will be used to make maps of U.S. energy expressed in equivalent units and from these a map of combined energy potentials for the country. Eight questions of energy theory will be explored.
SUPPORTED BY U.S. Dept. of Energy, Office of Technology Impacts, Div. of Regional Assessments

9.0007,
ENERGY BASIS FOR THE UNITED STATES
H.T. Odum, State University System of Florida, University of Florida, School of Engineering, Dept. of Environmental Engineering, *220 Black Hall, Gainesville, Florida* 32611 (EY-76-S-05-4398)
Energy analysis and simulation of quantitatively evaluated models are used to determine the energy basis of present and future alternatives of environmental and energy input to the economy of humanity and nature in the United States. Work includes calculation of energy embodied in main environmental inflow, energy embodied in catastrophes and toxicity, energy embodied in landscapes, energy coefficients for environmental inflows to a simplified input-output matrix of the U.S. economy, estimation of the spectral hierarchy of components of various energy quality to be expected in the U.S. in the future, energy analysis of environmental and urban system developing with strip mining in Florida phosphate and Montana coal, net energy of new solar technology, energy analysis of fisheries and new simulation of U.S. growth based on net energy.
Included are studies to verify energy theories: correlation of cost of transport of embodied energy to quality factor of that energy; correlation of energy control with energy quality; and need to match high- and low-quality energy to maximize power and economy.
SUPPORTED BY U.S. Dept. of Energy, Div. of Biomedical & Environmental Research

9.0008,
CONFERENCE - ALTERNATIVE ENERGY SOURCES-A NATIONAL SYMPOSIUM
Unknown, University of Miami, School of Engineering & Architecture, Clean Energy Research Inst, *Coral Gables, Florida* 33124 (EG-77-G-05-5569)
An international conference on Alternative Energy Sources has been organized. The conference addressed itself to the present state and future promise for all the alternative energy sources. It included sessions on solar energy, ocean thermal energy, wind energy, hydro and salinity gradient power, nuclear breeders and nuclear fusion, synthetic fuels from coal and wastes, hydrogen production and uses, formulation of workable policies on energy use and energy conservation. The conference, which was held on December 5-7, 1977, in Miami Beach, was attended by some 900 scientists, engineers and policy makers from 30 countries of the world.
SUPPORTED BY U.S. Dept. of Energy

9.0009,
PACIFIC REGIONAL ENERGY MANAGEMENT OF RESOURCE DEVELOPMENT PLANNING PROGRAM
H. Kono, Hawaii State Government, *Honolulu, Hawaii* (0431299)
Project provides energy environmental planning aid to Hawaii. Hawaii examines social, environmental costs, and benefits of such energy options as solar, geothermal, ocean thermal, biomass, and wind as alternatives to continued dependence on oil inputs and coal.
SUPPORTED BY U.S. Dept. of Energy, Office of Technology Impacts, Div. of Regional Assessments

9.0010,
CONFERENCES ON ENERGY ALTERNATIVES FOR HAWAII
P.K. Takahashi, University of Hawaii System, Manoa Campus, School of Engineering, Dept. of Civil Engin, *Bachman Hall, Honolulu, Hawaii* 96822 (OSS77-20723)
The University of Hawaii is going to conduct a general symposium, series of island work workshops and a general plenary session designed to: 1) raise the level of public consciousness and understanding of energy and energy-related matters; and 2) bring together the technical decision-making and grass-roots sectors of the community to develop a public statewide policy. First, a one-day informational and discussion symposium for some 500 participants will deal with energy conservation concepts, energy alternatives, and technological trade-offs. The symposium will be followed by a series of workshops, each including at least 100 participants, which will be held throughout the islands for the purpose of dealing with topics most relevant to their particular energy needs. These workshops will result in lists of citizen concerns about energy options for consideration by the State Legislature. Finally, a plenary session involving legislators, national leaders, business execu-

tives, as well as scientists and concerned citizens will be held in mid-1978 to integrate the various inputs into what might constitute a desirable statewide energy policy.

Hawaii has a rapidly expanding population, a heightened sense of citizen concern for the ecosystem, a wide range of available natural energy alternatives--solar, wind, geothermal, ocean thermal energy conversion, biomass--with an economy almost entirely dependent on petroleum. It is an appropriate site for studying the effect of public understanding of energy/technology issues and obtaining grass-roots developments of a public policy for energy that is based on adequate scientific and technological information.

SUPPORTED BY U.S. National Science Foundation, Office of Science & Society

9.0011,

DEVELOPMENT AND TEST OF A METHOD FOR INCREMENTAL ENERGY AND LABOR IMPACTS FROM CHANGES IN TECHNOLOGY

B.M. Hannon, University of Illinois, Urbana Champaign Campus, Graduate School, *Urbana, Illinois* 61801 (PRA79-12032)

The study seeks to relate changes in both energy consumption and the demand for labor to shifts in technology at the scale of individual industries. It will do this by calculating incremental changes in each of the products and services in each sector of the U.S. economy using detailed 367 sector Input-Output (I/O) analysis. Inputs to the model will be based on Department of Commerce data for 1963, 1967, and 1972, the most recent year available. The study will create, validate, compare, and use in several applications, a detailed set of incremental energy and labor impacts. Analysis of these impacts are useful to policymakers who wish to compare the impacts of alternate policy options involving dissimilar technologies. Examples are the new energy supply technologies (gasohol, solar powered satellites, and coal) versus conservation technologies (recycling scrap steel).

The research builds upon the author's previous work in average energy and labor impact analysis, in which the concept of 'energy cost' of energy and labor is more fully developed. One benefit of the incremental analysis over the average energy analysis is that it reflects only those facilities which would actually be affected by specific policy decisions. The technique thus provides a sensitive predictor of consequences of given policies.

SUPPORTED BY U.S. National Science Foundation, Directorate for Scientific Technological & Internat. Affairs, Div. of Policy Research & Analysis

9.0012,

ENERGY ALTERNATIVES FOR PUMPING IRRIGATION WATER

S.J. Clark, Kansas State University, School of Engineering, Dept. of Agricultural Engineering, *Anderson Hall, Manhattan, Kansas* 66502 (KAN-05-488)

OBJECTIVE: Conduct a feasibility study evaluating energy alternatives for pumping irrigation water. Alternatives considered will not use natural gas or petroleum products but will include: Solar, wind, biomass, conversion, coal. Energy storage to facilitate efficient utilization will be considered.

APPROACH: Energy sources and storage systems will be compared considering operational and capital costs, efficiency, implementation time, environmental impacts, land use, water use, constraints due to geographic and siting problems, significant technical uncertainties, effect on foreign dependency, and social impacts. Using existing data, computer simulation studies will relate design factors and weather data to the cost and performance of energy-storage systems. Systems will be considered for individual farmers and groups of farms.

PROGRESS: A feasibility study was performed to determine the most promising non-petroleum energy alternative for pumping irrigation water. Alternatives included (1) solar, (2) wind, (3) biomass conversion, and (4) direct combustion of coal. Large scale energy storage methods were included in combination with the energy alternatives. A standardized irrigation well (200 ft. to water level) was selected to provide a standard of comparison for the alternative systems. Pumping costs are being computed for the various systems. The main evaluation factor used to compare systems will be cost per acre inch pumped. Pumping cost must be less than the increase in crop value added by the water.

SUPPORTED BY Kansas State Government

9.0013,

SERVICE IN RELATION TO THE INTERNATIONAL ENERGY AGENCY (IEA)

M.E. McCormick, (No Performing Organization Reported), *Maryland* (ET-78-C-01-5306)

OBJECTIVES: Service in relation to the (IEA) Ocean Energy Working Group investigations of possible international cooperation in various ocean energy options.

APPROACH: Provide the necessary services as the United States representative in relation to the International Energy Agency (IEA) Ocean Energy Working Group investigations of international cooperation in the various ocean energy options, i.e.; wind, waves, salinity gradients, ocean thermal gradients, tides and currents. Provide a written report within two (2) weeks after completion of each conference.

SUPPORTED BY U.S. Dept. of Energy, Office of Solar Geothermal Electric & Storage Systems

9.0014,

LOW COST FLYWHEEL DEMONSTRATION

D.W. Rabenhorst, Johns Hopkins University, Applied Physics Lab., *Johns Hopkins Rd., Laurel, Maryland* 20810 (EC-77-C-01-5085)

The flywheel development program at the Applied Physics Laboratory has demonstrated the feasibility of advanced technology flywheels through the testing of relatively full scale (but light-weight) test articles. The present program will demonstrate the suitability of these flywheels for application in low cost, stationary energy storage systems, such as nighttime home storage, solar energy storage, wind energy storage, etc. The principal objectives of the program are as follows: (1) evaluate candidate low cost materials and flywheel configurations; (2) evaluate candidate bearing and seal systems; (3) demonstrate 20 watt hr/$ with a complete 1.0 kwh flywheel system; (4) demonstrate satisfactory safety characteristics; and (5) evaluate the operating characteristics of a 1 kwh rotor segment through appropriate tests in the following areas: design lifetime, vibration, shock, noise, acceleration, temperature and vacuum.

SUPPORTED BY U.S. Dept. of Energy

9.0015,

ENERGY CONSERVATION IN GRAIN (CORN) DRYING WITH COMBINATION METHODS

R.V. Morey, University of Minnesota, St. Paul Campus, Agricultural Experiment Station, Dept. of Agricultural Engineering, *St. Paul, Minnesota* 55101 (EM-78-S-02-4928)

SUPPORTED BY U.S. Dept. of Energy

9.0016,

CONSTRAINTS ON INCREASED USE OF APPROPRIATE ENERGY TECHNOLOGIES

D.L. Meadows, Dartmouth College, Graduate School, Dept. of Engineering SC, *P.O. Box 833, Hanover, New Hampshire* 03755

Computer simulation studies of social, economic, environmental, technical, and institutional constraints on the growth in use of alternative energy sources such as coal synthetic fuels, wood-fired power plants, low head hydro facilities, wind power, etc. The work is undertaken for specific clients with responsibility for decisions governing R and D, legislation, or regulation in various fields governing the use of energy. A list of reports is available from the program office; more than 80 reports and books are available on the research. Most provide complete details of the computer programs that have been developed.

BIBLIOGRAPHIC REFERENCES: Alternatives to Growth--I, Dennis Meadows, Ballinger Books, 1977, Cambridge, Mass.

SUPPORTED BY U.S. Dept. of Energy

9.0017,

ALTERNATIVE FUELS/ENERGY SOURCES FOR NON-HIGHWAY TRANSPORT

E.N. Lart, Exxon Research & Engineering Co., *P.O. Box 101, Florham Park, New Jersey* 07932 (5438)

The objectives are to prepare and present findings of Nonhighway Alternative Energy Source Study to industry and government groups and organizations to be selected by DOE. Utilizing information provided under the basic alternative fuel study and the forecast of possible fuels and prime movers of the near (1985), mid (2000), and long-range (2000) timeframes, the implications of contingency scenarios in which energy supplies are unexpectedly disturbed will be developed and evaluated. Consideration will be given to alternative fuel availabilities and leadtimes, interchangeability of fuel use between modes and equipment multi-fuel capabilities. Alternative fuels examined will include, but not be limited to, alcohol fuels from biomass, shale, and coal derived fuels and hydrogen both as a fuel and a feedstock for synthetically derived fuels. The logistics of supplying coal to the international marine trade will be studied by: (1) investigating U.S. and Free World port capabilities for handling coal, (2) examining forecasts of future international coal movements, and (3) determining the current and future potential for coal in the international marine trade. The Free World availability for alternative aircraft fuel will be examined, the options available to foreign countries in the area of alternative fuels will be determined and the influence of these options on international aircraft fuel supplies will be projected.

SUPPORTED BY U.S. Dept. of Energy

9.0018,

AN ENERGY CONVERSION SHOWPLACE

R.D. Weber, Mercer County Area Vocational School, Assunpink Center, *Armstrong Hall, c/o Trenton St. Coll. Room 15, Trenton, New Jersey* 08625 (VTP-3660)

The purposes of this energy conversion project are to: (1) provide instruction in the design, installation, operation, and evaluation of energy-conversion devices related to the sun, wind, and fossil fuels; (2) install two solar-heated domestic hot water heaters; (3) install and monitor a wind-data compulator to monitor wind speed and direction; (4) install an operable wind-powered electrical generator with a synchronous invertor to supplement the commercial electrical power used in one building; and (5) install a high-efficiency wood-burning stove in one building to supplement the existing oil-fired space-heating system. The equipment will be designed, installed, operated, and evaluated by thirty participants: ten secondary school students, ten industrial arts teachers, and ten vocational education teachers. The project will be conducted in three stages. Stage I will consist of a series of four-hour seminars dealing with solar energy, high-efficiency wood-burning stoves, and wind-energy generators. Stage II will involve specific planning for the installation of the energy-conversion devices. Stage III will consist of a two-week summer period at the installation site where the energy conversion units will be installed, operated, and evaluated. The installation site is the Mohican Outdoor Resource Center, a 1,700-acre environmental center located in Blairstown, New Jersey.

SUPPORTED BY New Jersey State Government

9.0019,

POTENTIAL AREAS OF ENERGY CONSERVATION AND USE OF ALTERNATE ENERGY SOURCES IN AGRICULTURE IN N.C.

D.Y. Goswami, University of North Carolina, North Carolina Agricultural & Technical State University, School of Engineering, Dept. of Mechanical Engineering, *N. Dudley St., Greensboro, North Carolina* 27411 (NC.X-020-5-79-440-4)

OBJECTIVE: Study of current on-farm practices as followed in the state of North Carolina. Assessment of the energy needs of different farm operations in North Carolina. Identification of the areas of maximum potential for energy conservation and where solar energy and other non-conventional energy can be used.

APPROACH: The first phase of the project will involve the study of current on-farm practices in North Carolina which use some form of energy. At the same time an extensive literature review of energy research work in agriculture will be done. Energy use by each of the operations will be calulated and compiled. An economic analysis will be done to identify the potential for energy conservation and use of alternate sources of energy in agriculture.

SUPPORTED BY U.S. Dept. of Agriculture, Cooperative Research Office, North Carolina

9.0020,

ECONOMIC IMPACTS OF ENERGY DEVELOPMENT AND USE ON AGRICULTURE AND NATURAL RESOURCES

W. McMartin, North Dakota State University, Agricultural Experiment Station, Dept. of Agricultural Economics, *Fargo, North Dakota* 58103 (NRE-43-309-38-01)

OBJECTIVE: Analyze supply and demand factors that will influence the potential for fuel wood and home heating. Analyze the economic feasibility of

energy (biomass) crops, including land and water requirements, impacts on traditional crop production and environmental implications. Assess the economic implications of alternative coal and oil shale development and associated activities on environmental quality and the competition for resources in rural areas.

APPROACH: Assess the economic resource use and environmental implications of public programs to encourage 'energy farms.' Develop regional reports on current land and water use, the economic implications for future resource use, resource competition, and environmental quality resulting from alternative levels of coal and oil shale development, and related activities. Develop an interregional linear program to evaluate conflicting reclamation budgets from available literature, cooperation with other agencies within and without USDA, and limited empircal studies. Budgeting techniques and linear programming will be used to estimate water demand for energy development and to appraise the economic and environmental implications of alternative water supplies.

SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Natural Resource Economics Div.

9.0021,

ENGINEERING ENERGY LABORATORY SUPPORT

W.L. Hughes, Oklahoma State University, Agricultural Experiment Station, Dept. of Electrical Engineering, *107 Whitehurst Hall, Stillwater, Oklahoma* 74075

An information dissemination program, sponsored by the Electric Utility Industry, reports twice a year on developments in such diverse subjects as nuclear waste disposal, coal gasification and liquefaction, desulfurization, wind and solar energy, etc.

SUPPORTED BY Public Service Co. of Oklahoma

9.0022,

BRADFORD, MCKEAN COUNTY, PENNSYLVANIA, ENERGY DEVELOPMENT OPPORTUNITY

Unknown, Pennsylvania State Government, *Box 911, Harrisburg, Pennsylvania* 17126

The Commonwealth of Pennsylvania is submitting on behalf of Bradford Hospital an energy-related enterprise project. The objective of the proposed project is to conduct a study of the feasibility of construction of a multi-fueled wood, municipal solid waste, and coal heating plant to serve Bradford Hospital. This study will investigate the technical, legal and financial feasibility of installing a solid fuel boiler to provide heat and possibly cogenerated electricity and central air conditioning to service Bradford Hospital and the area's Senior and Junior High School.

The major elements in this study are: 1) review of energy audits prepared in accordance with DOE regulations for the Hospital and the Senior and Junior High School to determine energy consumption requirements for the Hospital and the School, as well as their general facility and site plans, specifications and measurements; 2) determine the technical feasibility of locating a solid fuel boiler plant on the Hospital grounds or in the immediate vicinity; size, locate and estimate system costs for a boiler and all associated facilities for: a) solid fuel boiler system with conventional fuel back up; b) boiler system using the existing boiler system for back up; and, c) converting the existing fire box boilers to solid fuel; 3) determine legal and financial feasibility of the above boiler plant; 4) contingent upon the above findings, determine the technical feasibility of extending heating distribution lines to the Senior and Junior High School. This will include consideration of the appropriate technology and routing and systems costs for the extension, as well as the costs of increasing boiler plant and fuel storage capacity at the Hospital; 5) contingent upon the above findings, determine the technical feasibility of equipping the City of Bradford to produce refuse derived fuel for the proposed boiler plant; 6) contingent upon the above findings, determine the fesibility of providing for: 1) absorption of central air conditioning machinery at the Hospital, and 2) the production of super-heated steam for Rankine cycle cogeneration, which would include evaluation of the appropriateness of the existing air conditioning, heating and electrical loads for these purposes.

SUPPORTED BY U.S. Appalachian Regional Commission

9.0023,

ECONOMIC IMPACTS OF ENERGY DEVELOPMENT AND USE ON AGRICULTURE AND NATURAL RESOURCES

M. Bailey, University of Pennsylvania, U.S. Dept. of Agriculture Economic Development Div., *Philadelphia, Pennsylvania* 19104 (NRE-43-309-42-06)

OBJECTIVE: Analyze supply and demand factors that will influence the potential for fuel wood and home heating Analyze the economic feasibility of energy (biomass) crops, including land and water requirements, impacts on traditional crop production and environmental implications. Assess the economic implications of alternative coal and oil shale development and associated activities on environmental quality and the competition for resources in rural areas.

APPROACH: Assess the economic resource use and environmental implication of public programs to encourage 'energy farms.' Develop regional reports on current land and water use, the economic implications for future resource use, resource competition, and environmental quality resulting from alternative levels of coal and oil shale development, and related activities. Develop an interregional linear program to evaluate conflicting reclamation budgets from available literature, cooperation with other agencies within and without USDA, and limited empirical studies. Budgeting techniques and linear programming will be used to estimate water demand for energy development and to appraise the economic and environmental implications of alternative water supplies.

SUPPORTED BY U.S. Dept. of Agriculture, Economics & Statistics Service, Natural Resource Economics Div.

9.0024,

UTAH WATER RESEARCH LABORATORY ENERGY RESEARCH AND DEVELOPMENT

J.P. Riley, Utah Higher Education System, Utah State University, Utah Water Research Lab., *Main Bldg., Office 104, Logan, Utah* 84321 (PRJER031-1)

Ongoing energy research studies coordinated through the Utah Water Research Laboratory are summarized as a package with a brief description of each task. (1) Energy accounting as a tool in water management alternatives: Energy accounting was used to demonstrate the use of this approach for the optimum deployment of finite resources. Using this procedure energy resource inputs are examined and compared for specific hydropower dams and geothermal power plants. (2) Assessment of energy potential of Great Salt Lake: Theoretically, there is a vast energy potential, both thermal and osmotic, existing in the brines of the GSL. This project will evaluate the technical and economic feasibility of tapping this large energy resource. (3) Use of geothermal and industrial effluent waters in space heating: Geothermal potential of warm springs in Utah were assessed and heat exchanger systems devised to utilize the highly saline waters generally available. (4) Fermentation process for converting plant materials into methane: A stable two-stage fermentation process capable of converting pure plant materials into methane was developed. (5) A study of energy development and water re-use within the Colorado River basin: An examination will be made of various alternatives for management of the discharge from power plant cooling systems within the Colorado River basin (including total containment, re-use for space heating, irrigation, and/or power generation), and evaporation suppression in reservoirs.

SUPPORTED BY U.S. Dept. of Energy

9.0025,

ASSESSMENT OF ENERGY INDUSTRY OCCUPATIONAL HEALTH PROBLEMS - EPA

D. Knowles, U.S. Dept. of Health & Human Services, Public Health Service, Center for Disease Control, National Inst. for Occupational Safety & Health, Division of Respiratory Disease Studies, *944 Chestnut Ridge Rd., Morgantown, West Virginia* 26505 (VKP-E10-204)

Continuing assessment of occupational health problems associated with energy industries is indicated. Replacement of the task order contract approach with an in-house assessment effort is recommended. Supplemental contracted assistance in certain areas through limited scope purchase orders or small contracts will provide effort not available in-house. Energy areas requiring assessment are magnetohydrodynamics, power generation, conservation, direct coal burning, and a variety of small energy areas (i.e., oil shale, tar sands, biomass, solar, geothermal, wind power, ocean thermal, tidal power, etc.)

The objective of this project is to provide information necessary for use in planning in-depth studies for use in the context of future criteria documents, and for support of the overall NIOSH energy program.

SUPPORTED BY U.S. Dept. of Health & Human Services, Public Health Service, Center for Disease Control, National Inst. for Occupational Safety & Health

9.0026,

THE WIND, WOOD AND SOLAR GROUP WIND ELECTRIC DEMONSTATION EXPERIMENTAL PROJECT

Unknown, Phillips High School, *Phillips, Wisconsin* 54555

SUPPORTED BY U.S. Dept. of Energy

9.0027,

SPECIALIZED RESEARCH EQUIPMENT - DATA ACQUISITION AND STORAGE EQUIPMENT

D.F. Adams, University of Wyoming, School of Engineering, Dept. of Mechanical Engineering, *P.O. Box 3435, University Station, Laramie, Wyoming* 82070 (CME79-23878)

This action is to assist in the purchase of digital data acquisition and high speed test equipment for use in the Department of Mechanical Engineering at the University of Wyoming. A Nicolet Digital Oscilloscope is being purchased by the University of Wyoming.

The grant funds are being used to acquire a Tektronix 7904 high speed storage oscilloscope. Both pieces of equipment are needed to support ongoing research work in composite materials as well as in wind energy, fossil fuels, materials science, fluid mechanics, combustion, and heat transfer, currently being conducted in the Mechanical Engineering Department.

SUPPORTED BY U.S. National Science Foundation, Directorate for Engineering & Applied Science, Div. of Civil & Mechanical Engineering

9.0028,

SOLAR RADIATION/BASE-DATA (SMHI)

L. Dahlgren, Sveriges Meteorologiska och Hydrologiska Institut, Climate Branch, *Box 923, S60119 Norrkoping, Sweden* (53 5562 151)

OBJECTIVE: To design a network for collecting climatological data for the solar energy and biomass program of the National Swedish Board for Energy Source Development.

APPROACH: A pilot study will be carried out to design a network for measuring climatological parameters, mainly solar radiation, to be utilized at the planning and design of solar energy and biomass systems. Parameters, sensors, data acquisition system and data reduction at the stations will be specified. The instrument market will be surveyed and a cost calculation will be presented. The possiblities of coordination with other projects such as the Board's wind and wave energy projects and SMHI's automatic project will be considered. Instruments will be tested and if necessary, modified to fill the requirements of the measuring program. Relevant experience gained in other countries will be studied.

INTENDED USE OF RESULTS: The recorded data will be used in the Board's planning and in research within the frame of the Board's program.

SUPPORTED BY Namnden for Energiproduktionforskning

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(See Building Components)

DUST
(See Also Air Pollutants)

DWARFISM

DYNAMOMETERS

ECHO SOUNDING
(See Acoustics)

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ECONOMIC MINERAL APPRAISALS

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*U.S. GOVERNMENT PRINTING OFFICE: 1981-0-522-011/3762